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ANNUAL REPORT  
OF THE  
BOARD OF REGENTS  
OF THE  
SMITHSONIAN INSTITUTION,  
SHOWING  
THE OPERATIONS, EXPENDITURES, AND CONDITION  
OF THE INSTITUTION  
FOR THE  
YEAR ENDING JUNE 30, 1887.

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PART I.

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WASHINGTON:  
GOVERNMENT PRINTING OFFICE,  
1889.

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FIFTIETH CONGRESS, FIRST SESSION.

*Concurrent resolution adopted by the House of Representatives July 28, 1888, and by the Senate October 1, 1888.*

*Resolved by the House of Representatives (the Senate concurring), That there be printed of the Report of the Smithsonian Institution and of the National Museum for the years ending June 30, 1886 and 1887, in two octavo volumes for each year, 16,000 extra copies of each, of which 3,000 copies shall be for the use of the Senate, 6,000 copies for the use of the House of Representatives, and 7,000 copies for the use of the Smithsonian Institution.*



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## LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

ACCOMPANYING

*The annual report of the Board of Regents of that Institution to the end of  
June, 1887.*

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SMITHSONIAN INSTITUTION,  
Washington, D. C., July 1, 1887.

*To the Congress of the United States:*

In accordance with section 5593 of the Revised Statutes of the United States, I have the honor, in behalf of the Board of Regents, to submit to Congress the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year ending June 30, 1887.

I have the honor to be, very respectfully, your obedient servant,  
SPENCER F. BAIRD,  
*Secretary of Smithsonian Institution.*

Hon. JOHN J. INGALLS,  
*President of the Senate, pro tem.*

Hon. JOHN G. CARLISLE,  
*Speaker of the House of Representatives.*

# ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION TO THE END OF JUNE, 1887.

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## SUBJECTS.

1. Proceedings of the Board of Regents for the session of January, 1887.

2. Report of the Executive Committee, exhibiting the financial affairs of the Institution, including a statement of the Smithsonian fund, and receipts and expenditures for the year 1886-'87.

3. Annual report of the Secretary, giving an account of the operations and condition of the Institution for the year 1886-'87, with the statistics of collections, exchanges, etc.

4. General appendix, comprising a selection of miscellaneous memoirs of interest to collaborators and correspondents of the Institution, teachers, and others engaged in the promotion of knowledge.

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The report of the National Museum for the year 1886-'87 will be published in a separate volume.



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# THE SMITHSONIAN INSTITUTION.

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## MEMBERS EX OFFICIO OF THE "ESTABLISHMENT."

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(January, 1887.)

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GROVER CLEVELAND, President of the United States.  
JOHN SHERMAN, President of the United States Senate.  
MORRISON R. WAITE, Chief-Justice of the United States.  
THOMAS F. BAYARD, Secretary of State.  
DANIEL MANNING, Secretary of the Treasury.  
WILLIAM C. ENDICOTT, Secretary of War.  
WILLIAM C. WHITNEY, Secretary of the Navy.  
WILLIAM F. VILAS, Postmaster-General.  
LUCIUS Q. C. LAMAR, Secretary of the Interior.  
AUGUSTUS H. GARLAND, Attorney-General.  
MARTIN V. MONTGOMERY, Commissioner of Patents.

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## REGENTS OF THE INSTITUTION.

(Full list given on the following page.)

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## OFFICERS OF THE INSTITUTION.

SPENCER F. BAIRD, *Secretary,*  
*Director of the Institution, and of the U. S. National Museum.*

SAMUEL P. LANGLEY,  
G. BROWN GOODE,  
*Assistant Secretaries.*

WILLIAM J. RHEES, *Chief Clerk.*

## REGENTS OF THE SMITHSONIAN INSTITUTION.

By the organizing act approved August 10, 1846 (Revised Statutes, title LXXIII, section 5580), "The business of the Institution shall be conducted at the city of Washington by a Board of Regents, named the Regents of the Smithsonian Institution, to be composed of the Vice-President, the Chief-Justice of the United States [and the Governor of the District of Columbia], three members of the Senate, and three members of the House of Representatives, together with six other persons, other than members of Congress, two of whom shall be resident in the city of Washington, and the other four shall be inhabitants of some State, but no two of the same State."

### REGENTS FOR THE YEAR 1887.

The Vice-President of the United States:

JOHN SHERMAN (elected President of Senate Dec. 7, 1885),

JOHN J. INGALLS (elected President of the Senate Feb. 26, 1887).

The Chief-Justice of the United States:

MORRISON R. WAITE.

United States Senators:

Term expires.

SAMUEL B. MAXEY (appointed May 19, 1881)..... Mar. 3, 1887

JUSTIN S. MORRILL (appointed February 21, 1883)..... Mar. 3, 1891

SHELBY M. CULLOM (appointed March 23, 1885)..... Mar. 3, 1889

RANDALL L. GIBSON *vice* Senator MAXEY (appointed Dec. 19, 1887). Mar. 3, 1889

Members of the House of Representatives:

OTHO R. SINGLETON (appointed January 12, 1886)..... Dec. 28, 1887

WILLIAM L. WILSON (appointed January 12, 1886)..... Dec. 28, 1887

WILLIAM W. PHELPS (appointed January 12, 1886)..... Dec. 28, 1887

Citizens of Washington:

JAMES C. WELLING (appointed May 13, 1884)..... May 13, 1890

MONTGOMERY C. MEIGS (appointed December 26, 1885)..... Dec. 26, 1891

Citizens of a State:

ASA GRAY, of Massachusetts (first appointed in 1874)..... Dec. 26, 1891

HENRY COPPÉE, of Pennsylvania (first appointed in 1874)..... Dec. 26, 1891

NOAH PORTER, of Connecticut (first appointed in 1878)..... Mar. 3, 1890

JAMES B. ANGELL, of Michigan (appointed January 19, 1887). .... Jan. 19, 1893

MORRISON R. WAITE, Chancellor of the Institution and *President of the Board of Regents.*

### *Executive Committee of the Board of Regents.*

JAMES C. WELLING.

HENRY COPPÉE.

MONTGOMERY C. MEIGS.

## JOURNAL OF PROCEEDINGS OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION.

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WASHINGTON, *January 12, 1887.*

In accordance with a resolution of the Board of Regents of the Smithsonian Institution fixing the time of the annual session on the second Wednesday in January of each year, the Board met this day at 10:30 o'clock A. M.

Present: The Chancellor, Chief-Justice MORRISON R. WAITE; Hon. JOHN SHERMAN, Hon. JUSTIN S. MORRILL, Hon. SHELBY M. CULLOM, Hon. OTHO R. SINGLETON, Hon. WILLIAM W. PHELPS, Dr. ASA GRAY, Dr. HENRY COPPÉE, Dr. JAMES C. WELLING, General MONTGOMERY C. MEIGS, and the Secretary, Prof. SPENCER F. BAIRD.

Excuses for non-attendance were read from Dr. NOAH PORTER and Hon. WILLIAM L. WILSON.

The Chancellor announced that since the last meeting of the Board one of its most valued and eminent members had deceased, Rev. Dr. JOHN MACLEAN, of Princeton, N. J.; whereupon Dr. Welling, chairman of the Executive Committee, offered the following:

### THE LATE DR. MACLEAN.

I trust that without too much presumption I may venture to offer a brief minute in humble tribute to the memory of our honored and lamented colleague, the late Dr. Maclean, not because I chance to hold the place he lately filled with so much dignity and usefulness on your Executive Committee, but because it is perhaps my good fortune to have known that venerable man for a longer period than has fallen to the lot of any other member of this Board. And yet I do not come with any words of formal eulogium. This is not the hour and this is not the place in which to essay anything like an elaborate delineation of the character which was expressed in the life and services of our late distinguished friend, a character no less remarkable for its beauty than for its strength.

The memoir of his long and useful career has already been written elsewhere in the record of a well-spent life, dedicated to the glory of God and the welfare of man. It is written in the annals of the great College, whose story he has told so well that for all the sons of Princeton it must remain "a possession forever," and which he was called to serve in every



post of duty and honor, from the humblest to the highest, rising by easy gradations, because by a natural ascent, from the chair of Tutor to that of Professor, from the chair of Professor to that of Vice-President, and from the chair of Vice-President to the honors of the Presidency in a critical period, when he was able to lay broad and deep the solid foundations on which others have builded. It is written in the annals of the Church to which he gave his sincere adhesion, whose pulpit he adorned no less by the sanctity of his life than by the steadfastness of his faith, and for the defense of whose doctrine and order he was called again and again to stand in its courts of highest judicature. It is written in the annals of the Smithsonian Institution, for whose prosperity he was willing to spend and be spent till the last day of his mortal career. And above all it is written in the pious recollections of a countless host of scholarly men, scattered in all parts of the land, who from year to year went forth from Nassau Hall carrying with them the name and memory of John Maclean embalmed in their hearts by a thousand acts of kindness and of love which transmuted the temporary ties of academic relation into "hooks of steel," binding to him a successive swarm of youth during two generations of men.

Of the ripeness and range of Dr. Maclean's scholarship there is no room to speak within the limits of this brief chronicle. He preferred to read the Bible of the old dispensation in the original Hebrew, not only that he might get as near as possible to "the lively oracles of God," but because Hebrew was to him a familiar tongue. In the Greek language and literature he was a master and for long years an expert professor. The Latin tongue he wrote with a facility and grace which caused his pen to be put in frequent requisition whenever, for the purposes of academic disquisition, a draught was to be made on the stately speech of ancient Rome. As a preacher, he was sound and logical. As a teacher, he was solid and thorough, looking rather to the substance than the form of his instruction. As an executive officer, he had that "wisdom of business" which Lord Bacon praises, because he never sought an end which he did not believe to be right, and therefore he was able to pursue all the ends he aimed at with the directness inspired by a clear intelligence and a pure heart. In all things he was the very soul of Christian honor.

Great and good as teacher, preacher, and ruler, the man in Dr. Maclean was something greater, better, and broader than any of the forms or manifestations under which he was officially called to reveal himself in the performance of his public functions. The man should always be greater than the functionary. As the altar which sanctifies the gift is greater than any gift that can be laid upon it, so Dr. Maclean was greater in the sweetness and light of his gentle and candid nature than was apparent to those who never knew the "hidden man of the heart;" for high and holy as were his gifts in the sight of men, those gifts received their best consecration from the altar of the sanctified manhood on which he reverently laid them.

Under the inspiration of these sentiments, I respectfully submit the following resolutions:

Whereas, since the date of the last meeting of the Board of Regents of the Smithsonian Institution, its members have been called to mourn the loss of their venerable and distinguished colleague, the late Rev. John Maclean, D. D., LL. D., sometime President of Princeton College, who held the office of Regent for the term of eighteen years, during seventeen of which he served on its Executive Committee with no less credit to himself than usefulness to the Institution: Therefore, be it

*Resolved*, That with a high appreciation of the varied, abundant, and intelligent labors which the late Dr. Maclean brought to the cause of culture, of truth, and of righteousness throughout the whole of his long, useful, and honorable career; with a grateful sense of the manifold services he rendered to the Smithsonian Institution, for whose welfare he worked without weariness and watched without flagging, even after he had begun to feel the burden of age; with profound sorrow for his death, mingled with reverence for his beautiful memory, and with thanksgivings for the serene and peaceful close of a finished life, as full of years as it was full of honors, we hereby testify and record our admiration of the exalted Christian character with which he dignified and adorned every station that he was called to hold in the eyes of men; our respect for the solidity of the learning which supported him in the high discharge of every professional duty, whether in the pulpit, the academic chair, or the post of executive administration; and lastly, in special recognition of the grateful savor which his genial presence never failed to shed on the deliberations of this council-chamber, our cheerful and loyal homage to the dignity of bearing and amenity of manners which made him as courteous in debate as he was wise in counsel, as gracious in all the relations of private life as he was inflexible in the maintenance of Christian honor and conscientious in the performance of public duty.

*Resolved*, That this preamble and resolution be spread on the minutes of the Board in respectful tribute to the services and memory of our venerated colleague, and that a copy of these resolutions be transmitted to the family of our deceased friend in token of the share we fain would take with them in this bereavement.

The resolutions were unanimously adopted by a rising vote.

The Chancellor announced the election, by joint resolution of Congress, of Dr. James B. Angell, President of the University of Michigan, to fill the vacancy in the Board occasioned by the death of Dr. Maclean.

The annual report of the Executive Committee for the fiscal year ending June 30, 1886, was presented by its chairman, Dr. Welling, who stated that it gave him pleasure to inform the Board that his colleagues, Dr. Coppée and General Meigs, and himself, after making a thorough and minute examination of the accounts, looking at every voucher and verifying the books and certificates, had not found a single error of omission or commission, and he was therefore able to say that there was the most gratifying evidence of the efficiency of the financial manage-

ment of the Institution, a fact especially noteworthy when the great magnitude and the variety of its transactions are considered.

He also called attention to a slight change in the form of the report, as now presented, from the reports lately presented to the Board. It was, however, a recurrence to the old practice, which had been changed a few years ago at the suggestion of a former member of the committee. It is the custom of the Institution every year to make advances for certain operations, which are subsequently refunded, and these advances, with the amounts received from sales of publications, re-payments for freight, etc., have been deducted from the gross expenditures. The statements in the report of the Executive Committee, as recently compiled, gave only the net or actual outlay from the income of the Smithsonian fund. But now it is thought better to spread the actual aggregate of these transactions on the record, so as to exhibit the full magnitude and distinctive nature of the operations. A statement is therefore made in the present report of the Executive Committee under the head of "Receipts for conducting special researches and collections," and "Repayments," to which we would direct attention.

He also stated that the committee had deemed it advisable to make a statement of all the moneys received and handled by the Institution on account of trusts committed to it by Congress, and on the last page of the report it would be seen that an exhibit was presented giving an abstract of everything under this head.

On motion of Mr. Sherman the report was received and adopted.

The Secretary presented his annual report for the year ending June 30, 1886, which in accordance with a resolution of the Board had been printed in advance of the meeting.

General Meigs asked if there was any point in the report that Professor Baird wished to emphasize or to ask action on, particularly in regard to additional buildings for the Museum.

Professor Baird replied that there was not; that in regard to the new building for the Museum the Board had already taken action and recommended it to Congress several years ago.

On motion of Mr. Cullom the report was accepted and approved.

On motion of Dr. Welling the following resolution was adopted:

*Resolved*, That the income of the Institution for the fiscal year ending June 30, 1888, be expended by the Secretary with full discretion as to the items, subject to the approval of the Executive Committee.

The Secretary presented a communication to the Board requesting permission to appoint Prof. S. P. Langley as Assistant Secretary in charge of Exchanges, Publications, and Library, and Mr. G. Brown Goode as Assistant Secretary in charge of the National Museum.

On motion of Mr. Morrill it was—

*Resolved*, That the appointment by the Secretary of Prof. S. P. Langley and Prof. G. Brown Goode as Assistant Secretaries of the Smithsonian Institution be approved.



A communication from M. M. Campbell, referred by the Secretary of the Interior, recommending the establishment at the Smithsonian Institution of a department of language and the introduction of a universal alphabet, was read.

Mr. Singleton stated that the Library Committee of Congress, of which he was chairman, had a similar proposition now under consideration; and on motion the communication was laid on the table.

Dr. Gray, from the special committee on the publication of the scientific writings of Professor Henry, reported that the work would form two volumes of about 500 pages each, the first of which was completed and a copy was upon the table. The second would be ready in a few weeks. A certain number would be given to the family of Professor Henry, and the remainder would be subject to the discretion of the Secretary.

On motion, the Board then adjourned *sine die*.



# REPORT OF THE EXECUTIVE COMMITTEE OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION.

The Executive Committee of the Board of Regents of the Smithsonian Institution respectfully submits the following report in relation to the funds of the Institution, the appropriations by Congress for the National Museum and other purposes, and the receipts and expenditures for the Institution and the Museum, for the year ending June 30, 1887.

## *Condition of the fund July 1, 1887.*

The amount of the bequest of James Smithson deposited in the Treasury of the United States, according to the act of Congress of August 10, 1846, was \$515,169. To this was added, by authority of Congress, act of February 8, 1867, the residuary legacy of Smithson and savings from annual income and other sources, \$134,831. To this \$1,000 was added by a bequest of James Hamilton, \$500 by a bequest of Simeon Habel, and \$51,500 as the proceeds of the sale of Virginia bonds owned by the Institution, making in all, as the permanent Smithsonian fund in the United States Treasury, \$703,000.

## *Statement of the receipts and expenditures of the Smithsonian Institution, July 1, 1886, to June 30, 1887.*

### RECEIPTS.

Cash on hand July 1, 1886 * .....	\$24,784.17
Interest on the fund, January 1, 1887 .....	21,090.00
Cash from sales of publications .....	\$561.44
Cash from repayments of freight, etc .....	799.18
	<hr/>
	1,360.62
Total receipts .....	\$47,234.79

### EXPENDITURES.

#### Building:

Repairs, care, and improvements .....	\$1,403.34
Furniture and fixtures .....	2,312.97
	<hr/>
	\$3,716.31

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\* This includes the semi-annual interest, \$21,090, received July 1, 1886.



Expenditures (carried over) .....	\$3,716.31
General expenses:	
Meetings .....	\$590.00
Postage and telegraph .....	523.02
Stationery .....	633.25
General printing .....	300.36
Incidentals .....	658.91
Books, periodicals, and binding .....	1,126.28
Salaries .....	22,732.17
	<hr/> 26,563.99
Publications and researches:	
Smithsonian Contributions .....	2,618.98
Miscellaneous Collections .....	3,497.62
Reports .....	1,969.48
Explorations and researches .....	2,690.08
Apparatus .....	72.08
	<hr/> 10,848.24
Exchanges:	
Literary and scientific exchanges .....	4,683.11
	<hr/> 4,683.11
Total expenditure .....	<hr/> \$45,811.65
Balance unexpended June 30, 1887 .....	1,423.14

The balances on hand July 1, 1886, as given in the last report, on account of funds intrusted to the Institution for conducting special researches, viz, from M. J. Jesup for collections of fish casts and building stones, \$87.21, and from J. Hotchkiss for research on coke, \$37.28, have been expended during the year, and these accounts have been closed.

The items of expenditure given above should be credited with the cash received from miscellaneous sources, sales, etc., as follows:

Building .....	\$20.40
Furniture .....	12.10
Postage .....	2.80
General printing .....	1.50
Incidentals .....	38.95
Books, periodicals, and binding .....	14.00
Smithsonian Contributions .....	125.99
Miscellaneous Collections .....	416.77
Reports .....	18.68
Explorations and researches .....	12.95
Exchanges .....	696.48
	<hr/> 1,360.62

The net expenditure of the Institution for the year was, therefore, \$44,451.03, or \$1,360.62 less than the total expenditure, \$45,811.65, above given.

All the moneys received by the Institution from interest, sales, refunding of moneys temporarily advanced or otherwise, are deposited with the Treasurer of the United States to the credit of the Secretary

of the Smithsonian Institution, and all payments are made by his checks on the Treasurer.

*Exhibit of the condition of the appropriations by Congress for the Smithsonian Institution and National Museum, July 1, 1887.*

## SMITHSONIAN INSTITUTION.

Appropriations.	Balances July 1, 1886.	Appropriation for 1886-'87.	Expended to June 30, 1887.	Balances July 1, 1887.
International exchanges, 1887.....	.....	\$10,000.00	\$10,000.00	None.
Ethnological researches:				
1886 .....	\$869.13	.....	869.13	None.
1887 .....	.....	40,000.00	33,446.92	\$6,553.08
Smithsonian Institution, building repairs.....	.....	15,000.00	131.80	14,868.20

*Ethnological researches.*—An appropriation of \$40,000 was made by Congress for the fiscal year ending 30th June, 1887, for the prosecution of ethnological researches under the direction of the Secretary of the Smithsonian Institution. The actual conduct of these investigations has been placed by the Secretary in the hands of Maj. J. W. Powell, director of the Geological Survey. The abstracts of expenditures and balance sheets for this appropriation have been exhibited to us; the vouchers for the expenditures are, however, transmitted, after approval by the Secretary, to the accounting officers of the Treasury Department for settlement.

The balance available to meet outstanding liabilities on the 1st of July, 1887, as reported by the official disbursing agent, is \$6,553.08.

## NATIONAL MUSEUM.

*Statement of accounts.*

Appropriations.	Balances July 1, 1886.	Appropriation for 1886-'87.	Expended to June 30, 1887.	Balances July 1, 1887.
Preservation of collections:				
1885 .....	\$2.00	.....	.....	\$2.00
1885-'86 .....	53.88	.....	\$52.40	1.48
1886 .....	1,841.61	.....	1,839.65	1.96
1887 .....	.....	\$106,500.00	100,508.83	5,991.17
Armory:				
1885 .....	8.25	.....	.....	8.25
1886 .....	214.54	.....	168.40	46.14
Furniture and fixtures:				
1885 .....	.16	.....	.....	.16
1886 .....	4,012.84	.....	3,967.79	45.05
1887 .....	.....	40,000.00	37,190.20	2,809.80
New building—sidewalk, 1885 .....	101.38	.....	101.38	None
Heating and lighting, etc., 1887.....	.....	11,000.00	10,608.27	391.73

## RECAPITULATION.

The total amount of the funds administered by the Institution during the year ending 30th of June, 1887, appears, from the foregoing statements and the account-books, to have been as follows:

<i>Smithsonian Institution.</i>	
From balance of last year.....	\$24,784.17
From interest on the Smithsonian fund.....	21,090.00
From M. K. Jesup for collections.....	\$87.21
From J. Hotchkiss for research.....	37.28
	<hr/> 124.49
From repayments for freight, explorations, etc.....	\$799.18
From sales of Smithsonian publications.....	561.44
	<hr/> 1,360.62
	<hr/> \$47,359.28

Appropriations committed by Congress to the care of the Institution for the year 1887, and balances of appropriations unexpended in previous years:

Reconstructing and furnishing eastern portion of Smithsonian building.....	\$70,600.00
International exchanges.....	10,000.00
Ethnological researches.....	40,869.13
Smithsonian Institution, building repairs.....	15,000.00
Preservation of collections.....	108,397.49
Preservation of Armory.....	222.79
Furniture and fixtures.....	44,013.00
Museum building sidewalk.....	101.38
Heating, lighting, electric and telephone service.....	11,000.00
	<hr/> 300,203.79
	<hr/> \$347,563.07.

The committee has examined the vouchers for payments made from the Smithsonian income during the year ending 30th June, 1887, all of which bear the approval of the Secretary of the Institution, and a certificate that the materials and services charged were applied to the purposes of the Institution.

The committee has also examined the accounts of the National Museum, and find that the balances above given correspond with the certificates of the disbursing officers of the Interior and Treasury Departments.

The quarterly accounts current, the vouchers, and journals have been examined and found correct.

*Statement of regular income from the Smithsonian fund, to be available for use in the year ending 30th June, 1888.*

Balance on hand June 30, 1887.....	\$1,423.14
Interest due and receivable, July 1, 1887.....	21,090.00
Interest due and receivable, January 1, 1888.....	21,090.00

Total available for year ending June 30, 1888.....\$43,603.14

Respectfully submitted.

JAMES C. WELLING,  
HENRY COPPÉE,  
M. C. MEIGS,  
*Executive Committee.*

WASHINGTON, July 21, 1887.



# REPORT OF PROFESSOR BAIRD, SECRETARY OF THE SMITHSONIAN INSTITUTION,

FOR THE YEAR ENDING JUNE 30, 1887.

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*To the Board of Regents of the Smithsonian Institution :*

GENTLEMEN : I have the honor to present herewith the report of the operations and condition of the Smithsonian Institution for the year 1886-'87.

There is also given, in accordance with established usage, a summary of the work performed by the branches of the public service placed by Congress under its charge, namely, the National Museum and the Bureau of Ethnology.

## THE BOARD OF REGENTS.

By the organic law of August 10, 1846, the Vice-President of the United States is made a member of the Board of Regents ; and in the absence of a Vice-President, it has been held that the President of the United States Senate occupies the same position. At the date of the last annual report, Hon. John Sherman, by virtue of his office as the acting Vice-President *pro tempore*, was a Regent of the Institution. In consequence of his resignation of that office, the Hon. John James Ingalls was elected by the United States Senate its President, February 26, 1887 ; and is accordingly a Regent.

The only other change in the Board since the last annual report is the vacancy occasioned by the death of the Rev. Dr. John Maclean (formerly president of Princeton College), who was so long identified with the history of the Institution and so closely associated with its late Secretary, Professor Henry. Dr. Maclean died August 10, 1886, and as a just mark of respect to his memory the building was closed on the day of his funeral, August 13, 1886.

The action of the Board in regard to Dr. Maclean was the adoption of the following resolutions after an eloquent and feeling tribute had been paid to his memory by Dr. James C. Welling, chairman of the Executive Committee, whose remarks in full will be found in the journal of proceedings of the Board of Regents :

“ Whereas since the date of the last annual meeting of the Board of Regents of the Smithsonian Institution, its members have been called

upon to mourn the loss of their venerable and distinguished colleague, the late Rev. John Maclean, D. D., LL. D., sometime president of Princeton College, who held the office of Regent for the term of eighteen years, during seventeen of which he served on its Executive Committee with no less credit to himself than of usefulness to the Institution: Therefore, be it

*Resolved*, That with a high appreciation of the varied, abundant, and intelligent labors which the late Dr. Maclean brought to the cause of culture, of truth, and of righteousness throughout the whole of his long, useful, and honorable career; with a grateful sense of the manifold services he rendered to the Smithsonian Institution, for whose welfare he worked without weariness, and watched without flagging even after he had begun to feel the burden of age; with profound sorrow for his death, mingled with reverence for his beautiful memory, and with thanksgiving for the serene and peaceful close of a finished life, as full of years as it was full of honor, we hereby testify and record our admiration of the exalted Christian character with which he dignified and adorned every station that he was called to hold in the eyes of men; our respect for the solidity of the learning which supported him in the high discharge of every professional duty, whether in the pulpit, the academic chair, or at the post of executive administration; and lastly, in special recognition of the grateful savor which his genial presence never failed to shed on the deliberations of this council chamber, our cheerful and loyal homage to the dignity of bearing and amenity of manners which made him as courteous in debate as he was wise in council, as gracious in all the relations of private life as he was inflexible in the maintenance of Christian honor and conscientious in the performance of public duty.

*Resolved*, That this preamble and resolution be spread on the minutes of the Board in respectful tribute to the services and memory of our venerated colleague, and that a copy of these resolutions be transmitted to the family of our deceased friend in token of the share we fain would take with them in this bereavement."

Congress by joint resolution, approved by President Cleveland January 19, 1887, filled the vacancy on the Board of Regents occasioned by the death of Dr. Maclean by the election of Dr. James B. Angell, president of the University of Michigan.

#### FINANCES.

The Smithsonian fund in the Treasury of the United States remains the same as stated in the last report, \$703,000.

The receipts and expenditures for the year ending 30th of June, 1887, are as follows:

#### RECEIPTS.

Cash on hand July 1, 1886 (including July interest on the fund) .....	\$24,784.17
Interest on the fund January 1, 1887 .....	21,090.00
Cash from repayments, sales, etc .....	1,360.62
<b>Total receipts.....</b>	<b>\$47,234.79</b>

## EXPENDITURES.

Building, furniture, and fixtures.....	\$3,716.31
General expenses, salaries, etc .....	26,563.99
Publications and explorations.....	10,848.24
Literary and scientific exchanges.....	4,683.11
	<hr/>
Total expenditure.....	\$45,811.65
	<hr/>
Balance cash on hand .....	1,423.14

The vouchers and account-books have been examined quarterly by the Executive Committee, who report them all correct, and that the Smithsonian fund and balance stated above are in the Treasury of the United States. A more detailed account of the expenditures of the Institution is given in the report of the Executive Committee.

## ASSISTANT SECRETARIES.

Having consulted with Prof. Samuel P. Langley, director of the Allegheny Observatory, Pennsylvania, with a view of securing his services as Assistant Secretary of the Institution, without asking from him the abandonment of his great scientific researches or a withdrawal from his observatory, I ascertained that he was willing to devote a considerable portion of his time to the object mentioned.

Accordingly, at the last annual meeting of the Regents, after representing to them the onerous nature of the duties of the Secretary, from their increasing range and importance, I requested permission to appoint two assistant secretaries, which appointment would be in a certain sense a return to the organization of the Institution in 1850, when Mr. Charles C. Jewett was assistant in charge of the library, and myself assistant in charge of the museum collections, and later of the exchanges as well. I therefore asked leave to nominate Prof. Samuel P. Langley Assistant Secretary in charge of the exchanges, publications, and library, and Mr. G. Brown Goode Assistant Secretary in charge of the National Museum. These nominations were unanimously confirmed by the Board; and the two gentlemen named were, on the 12th day of January, 1887, appointed Assistant Secretaries of the Smithsonian Institution.

Subsequently, in consequence of my enforced absence from the Institution by reason of sickness, Professor Langley was appointed by the Chancellor, February 10, 1887, Acting Secretary, under the provisions of the act of Congress of May 13, 1884, and this position he continues to occupy at the date of the present report.

## PORTRAIT OF SMITHSON.

A water-color portrait of James Smithson, in the possession of Mr. James Gunn, of 49 Bedford street, Strand, London, having been offered to the Institution for 30s., our agent, Mr. Wesley, of London, was au-



thorized to conclude the purchase if found satisfactory. By letter dated May 19, 1887, the purchase of the likeness, at £1 10s., was approved; and the colored drawing was forwarded to this Institution, where it will be deposited with the other relics of Smithson. The water-color is 7 inches by 6 inches in size, representing Smithson in his academic cap and gown (at the age of probably twenty-five years), and is in a fresh and excellent condition.

#### BUILDINGS.

*Smithsonian Building.*—The western corridor, or range, connecting the main building of the Institution with its extreme western wing, in which have been deposited of late years all the large alcoholic collections of the National Museum and of the Fish Commission, not having its floors, ceilings, and roof originally built fire-proof, representation has several times been made to Congress that the United States national collections were thereby seriously endangered, and that a moderate appropriation for providing against such risk was eminently just and advisable. At the last session of Congress an appropriation of \$15,000 was granted for putting this range in good fire-proof condition. Proposals for the work were at once published, and the desired repairs have been commenced and will be vigorously pushed forward.

*National Museum Building.*—The building erected by Government for the National Museum, at a remarkably small cost, continues to give satisfaction in every particular excepting in its extent. The overflowing wealth of the collections cannot at present be properly displayed or protected; and the necessity of additional accommodations becomes every year more pressing. The Regents having authorized some years ago an application to Congress for relief, the present opportunity should not be neglected for again respectfully and urgently pressing upon the attention of Senators and Members of the House of Representatives the claims of the National Museum for an additional building, at least as large as the present one.

*Armory Square.*—A communication dated June 1, 1887, was received from Col. John M. Wilson, in charge of the public buildings and grounds, informing me that it was proposed to re-name Armory Square (extending from Sixth to Seventh streets, and from B street north to B street south), after our late distinguished Secretary, the "HENRY PARK." The adjoining triangular reservation, extending eastward from Sixth street to Third street, is now known as the *Seaton Park*.

To this communication an expression of cordial approval was returned to Colonel Wilson, through the Acting Secretary, Professor Langley.

#### CORRESPONDENCE.

This important branch of Smithsonian operations embraces a wide range of applications and of topics in addition to the necessarily large

number of business and routine letters constantly required in the transaction of its daily work. From all portions of our country inquiries and proposals are continually received, varying from modest requests for information on subjects frequently common-place, sometimes abstruse, to magisterial announcements of new philosophies and cosmologies, destined to revolutionize science or to entirely supersede the laws of Newton. Agreeably to its established policy, all correspondents receive a respectful attention and reply, and if the information sought is not immediately accessible, either reference is given to other establishments or sources, or specialists are addressed upon the subject, and the Institution itself becomes a solicitor of knowledge.

The number, however, of those ambitious of having their visionary speculations published by the Institution has been so considerable that for several years past the following circular has been largely employed in response :

“SMITHSONIAN INSTITUTION, WASHINGTON, D. C.

“This Institution being in frequent receipt of communications announcing discoveries or theories supposed by the writers to be both new and important, it may be well to inform these correspondents that owing to the number of such papers the usual course is to refer them to one or more specialists in the particular subject discussed, and to communicate briefly by letter to the authors the result of such examination. This may sometimes involve a delay of several weeks before the expected answer is returned.

“In order to correct a very common misapprehension, it is proper to state that the Institution has not offered any standing prizes for the solution of difficult problems, or for the discovery of new scientific principles. The proper course for those who wish to obtain pecuniary advantage from their supposed contributions to knowledge, is to make some practical application thereof, for which they may secure a patent from the United States Patent Office. It may also be remarked that a rule adopted by the Board of Regents forbids the Secretary or his assistants giving, for personal benefit, an official opinion as to the merits or demerits of inventions or other projects.”

EXPLORATIONS.

A full account of the explorations and accessions resulting therefrom undertaken during the past year under the auspices of the Institution will be found in the report of Mr. Goode, upon the Museum, forming the second part or volume of the Regents' Report. Only a brief reference, therefore, to one or two subjects appears necessary in this place.

*Exploration for American bison.*—An unsuccessful attempt having been made the previous year to procure specimens of the buffalo (now being rapidly exterminated), at the request of Mr. W. T. Hornaday another attempt was approved and determined upon.

Early in the spring of 1886 the attention of the Secretary was called to the fact that the work of exterminating the American bison had made most alarming progress, and also that the representatives of this

species then in the National Museum were far from being what they should be. A careful inventory revealed the fact that the collection contained only two male specimens which were very old and in a sadly dilapidated condition, a single cow, an unmounted cow-skin, and one mounted male skeleton. The efforts which had been made by correspondence during the previous year had signally failed to produce any specimens. Realizing the imperative need of securing at once and at all hazards a complete and unexceptional series of fresh skins for mounting, before it should become too late, the Secretary directed the chief taxidermist, Mr. Hornaday, to take immediate steps toward the accomplishment of that end.

At first all inquiries in regard to the presence of wild buffalo were met by the assurance that those animals had all been killed, and that none remained outside of the Yellowstone Park. Eventually, however, reports were received to the effect that a few individuals still remained in Montana, and a few more in the panhandle of Texas. Inasmuch as the task of finding specimens threatened to be the most serious part of the undertaking, and might possibly require two or three months' search, it was decided not to wait until the proper hunting season in the fall and winter months, but to send the party at once on its quest. Accordingly Mr. Hornaday started immediately for Montana, and by following up the most reliable information he obtained, had the exceeding good fortune to find a locality, about 75 miles northwest of Miles City, which contained about fifty or sixty head of buffalo. Owing to the fact that the people along the Yellowstone and Missouri Rivers were generally quite ignorant of the existence of those animals in that wild and uninhabited region, the bison had found safe shelter there ever since the great northern herd was swept out of existence in the years 1881, 1882, and 1883, and were breeding there in fancied security. But the settlement of that country by the ranchmen, which had just then taken place, doomed every one of those animals to destruction at the hands of the cowboys, and the sequel has proved that Mr. Hornaday's efforts were put forth only just in time to snatch a few specimens from the total annihilation that has overtaken the millions.

Mr. Hornaday's party prosecuted its search until three buffaloes were actually taken, one a very young calf, which was caught alive and so taken to Washington, and two old bulls, which were killed and preserved. As was fairly expected, they had so far shed their winter pelage that their skins were worthless, but their heads and entire skeletons were taken. Having thus actually located a band of bison the party returned to the Smithsonian without delay, to go out again in the fall to accomplish the remainder of its task.

In the latter part of September, Mr. Hornaday again took the field, and in a little over two months succeeded in finding about twenty-eight head of buffalo. By dint of hard work and no small amount of personal



risk twenty-two specimens were killed and preserved in the finest possible condition, and at the same time the chief taxidermist was afforded a fine opportunity for making life studies of the species. The finest and largest of the eight bulls was actually studied and sketched as he stood on the prairie, wounded and at bay, only 30 yards distant.

In addition to the splendid series of skins of all ages and sexes thus collected, which in view of the almost complete extinction of the species we may fairly consider of almost priceless value, the party collected sixteen complete skeletons, fifty-one dry skulls, two foetal young in alcohol, and a very fine series of skins and skeletons of prong-horn antelope, coyote, and a few deer. A fine collection of skeletons of birds of all species found was also made for the department of comparative anatomy.

This exploration has not only yielded a collection of great value to the National Museum, and such as could not have been obtained in any other way, but it has also secured to science a large number of valuable duplicates such as will be eagerly sought after a very few years hence, when the last specimen of *Bos americanus* has been slaughtered. Indeed, so rapidly is the destruction of our great game animals being prosecuted in every part of the United States, it is a sad certainty that in a very few years the elk, mountain sheep, goat, deer, moose, and other forms will have *totally disappeared*. In view of this prospect, more stringent measures of game protection and preservation are loudly called for.

A full report of the above exploration and its results will be found in the Report of the U. S. National Museum, already referred to.

*Other fields of exploration.*—A proposal was made (August 2, 1886) to Mr. C. H. Townsend that he undertake an exploration of the Swan Islands, in the Caribbean Sea (belonging to the Pacific Guano Company), said to abound in land birds in great variety, and also in large iguana and other reptiles, in the belief that the exploration of these islands will afford an excellent opportunity for a naturalist to make a monograph of great interest. Messrs. Glidden & Curtis having made a courteous offer to accommodate a naturalist on board of one of their vessels about to sail for that region, due acknowledgment was made for the favor; and later, additional thanks were called for (November 15, 1886) by their placing one of their vessels at Mr. Townsend's disposal, for the reception of such collections as he might secure for the National Museum.

An appropriation was made to assist Mr. J. A. McNiell in collecting antiquities from the Isthmus of Panama for the National Museum.

The acquisition for the ethnological collections, of the Easter Island idol, and of other interesting articles, will be fully detailed in the Report, Part II, devoted to the condition of the National Museum.

## PUBLICATIONS.

The publications of the Institution may be said to now comprise four series. First, the "Smithsonian Contributions to Knowledge" in quarto form, presenting the results of original research (corresponding generally with the transactions of learned societies), of which 25 volumes have been published. Second, the "Smithsonian Miscellaneous Collections," in octavo form, presenting papers, tabulations, classifications, and other compilations, generally of a more technical and practical character, of which 30 volumes have been published. Third, the "annual reports of the Board of Regents of the Institution" to Congress, in octavo form, containing, in addition to the exposition of the operations and condition of the Institution, papers from correspondents illustrating the progress of scientific investigation, of which 40 volumes have been published. Fourth, the more recent series of "Annual Reports of the Bureau of Ethnology" in imperial octavo form, of which 4 volumes have been published.

*Smithsonian Contributions to Knowledge.*—The only memoir of this series actually issued during the past fiscal year, is "Researches upon the Venoms of Poisonous Serpents," by S. Weir Mitchell, M. D., and Edward T. Reichert, M. D. This forms a quarto volume of 196 pages, illustrated by 4 cuts inserted in the text and 5 colored plates. This work was leaving the printer's hands at the close of the last fiscal year, though it was not actually published until the beginning of the present fiscal year, and it was fully described in the last annual report.

*Smithsonian Miscellaneous Collections.*—Numerous papers belonging to this series have been published during the past year, and 3 complete volumes have been collected from the published papers on hand. These have been selected without reference to their chronological order, but mainly with regard to the average size of the resulting volume, and also with some attention to congruity of compilation. The numbers prefixed to the following titles indicate merely their order in the official catalogue of publications.

512. "List of Institutions in the United States receiving Publications of the Smithsonian Institution," comprising over 1,800 addresses, with a prefatory statement of the rules for the distribution of publications. Octavo, xii+72 pages.

522. "Miscellaneous Collections. Vol. XXVIII." The fourth edition (revised and enlarged) of "Tables Meteorological and Physical." By Arnold Guyot, LL. D., edited by William Libbey, jr. Octavo, xxv+747 pages. This is a reprint for the Miscellaneous Collections of the edition published in 1884, and was fully described in the Smithsonian report for 1884-'85.

536. "List of Astronomical Observatories." By George H. Boehmer. This is a simple list of the observatories, American and foreign, alpha-

betically arranged, without the details of information given in similar preceding lists. (Reprinted from the Smithsonian report for 1885.) Octavo, 16 pp.

546. "Miscellaneous Collections. Vol. XXIX." This is "A Catalogue of Scientific and Technical Periodicals (1665 to 1882), together with Chronological Tables, and a Library Check-List." By Henry Carrington Bolton. This volume is a reprint for the Miscellaneous Collections of the work previously published in 1885 (No. 514), and fully described in the Smithsonian report for 1885-'86. Octavo, x+773 pages.

550. The "Scientific Writings of Joseph Henry," in two royal octavo volumes; bound to correspond with the "Henry Memorial Volume" (published by order of Congress). The first volume contains xii+523 pages, including index, and is illustrated by 46 cuts inserted in the text. The second volume contains viii+559 pages, including index, and is illustrated by 48 cuts inserted in the text. This work is fully described in the Smithsonian report for 1885-'86.

558. "Miscellaneous Collections. Vol. XXX." The "Scientific Writings of Joseph Henry." This edition of the work just above referred to is reprinted on medium octavo paper, for the "Miscellaneous Collections" series, from the same stereotype plates. It forms a single octavo volume of 1105 pages.

645. "Miscellaneous Papers relating to Anthropology." By George Ercol Sellers; Charles Whittlesey; J. P. MacLean; Charles C. Jones, jr.; James Shepard; Mark Williams; and the late Henry R. Schoolcraft. (Reprinted from the Smithsonian report for 1885.) An octavo pamphlet of 44 pages; illustrated by 19 cuts.

*Bulletins of the National Museum.*—This series consists of monographs of biological subjects, check-lists, taxonomic systems, etc., designed to illustrate the mineral, botanical, zoological, and ethnological material of the Museum, and are originally printed under the authority of the honorable Secretary of the Interior. These papers, prepared under the direction of the Smithsonian Institution, are necessarily of great variety in size and range: Bulletin No. 17, for example, covering but 51 pages; and Bulletin No. 27 occupying 1279 pages. A supplementary edition of the bulletins from the stereotype plates is issued by the Institution, and from time to time the issues are arranged or combined in volumes of its Miscellaneous Collections. Thus Bulletins Nos. 1 to 10, inclusive, formed Volume XIII of the Miscellaneous Collections. Bulletins Nos. 11 to 15, inclusive, formed Volume XXIII; and Bulletin 16 formed Volume XXIV. Bulletins 17 and following have not yet been gathered into the Miscellaneous Volumes.

625. "Bulletin of the U. S. National Museum, No. 30. Bibliography of Publications relating to the Collection of Fossil Invertebrates in the U. S. National Museum, including complete lists of the writings of Fielding B. Meek, Charles A. White, and Charles D. Walcott." By John



Belknap Marcou. This forms the third volume of the "Bibliographies of American Naturalists." Octavo, 333 pages.

653. "Bulletin of the U. S. National Museum, No. 31. Synopsis of the North American Syrphidæ." By Samuel W. Williston. Octavo, 335 pages; illustrated by 12 plates of outline cuts.

*Proceedings of the National Museum.*—This series, like the preceding, are primarily printed under the authority of the honorable Secretary of the Interior. The papers, however, are shorter and less elaborate, and are designed to give early accounts of recent acquisitions to the Museum, or of freshly acquired facts relating to biology, etc. And to this end such papers are promptly published in single "signatures" as soon as matter sufficient to fill 16 pages has been prepared, the date of issue being given on each signature. The publication thus partakes of the character of an irregular periodical, the numbers of which, continuously paged, form a regular annual volume. These volumes, like the bulletins, are from time to time included in the Miscellaneous Collections. The "Proceedings," Vol. I, for 1878, and Vol. II, for 1879, together formed Vol. XIX of the Miscellaneous Collections. "Proceedings," Vol. III, for 1880, and Vol. IV, for 1881, together formed Vol. XXII of the Miscellaneous Collections. "Proceedings," Vol. V and following have not yet been collected into the "Miscellaneous" series.

637. "Circular for the Guidance of Persons desiring to make Exchanges of Birds or Birds' Eggs with the National Museum." A one-page octavo circular (No. 34).

646. "Circular concerning the Lending of Typical Specimens." A one-page octavo circular (No. 35). These circulars are inserted as an appendix to the volume of "Proceedings."

650. "Proceedings of the U. S. National Museum, Vol. IX, 1886." The volume contains descriptive and systematic papers by James E. Benedict, T. W. Blackiston, George H. Boehmer, Charles H. Bollman, Edward D. Cope, W. H. Dall, George E. Doering, Charles L. Edwards, Carl H. Eigenmann, Barton W. Evermann, Fernando Ferrari-Perez, Morton W. Fordice, Charles H. Gilbert, Elizabeth G. Hughes, David S. Jordan, George N. Lawrence, John Belknap Marcou, William G. Mazyck, George P. Merrill, Richard Rathbun, Robert Ridgway, John A. Ryder, Rosa Smith, Leonhard Stejneger, John B. Smith, Frederick W. True, and John Grant Wells. An octavo volume of v+ 714 pages, illustrated by 25 plates (1 colored, the rest cuts).

*Smithsonian Annual Reports.*—These reports being submitted to Congress as required by the organic law, are printed by order of that body. Much of the contents, however, are reprinted by the Institution at its own expense.

648. Report of the U. S. National Museum (under the direction of the Smithsonian Institution) for the year 1884." This volume forms Part II of the Annual Report of the Smithsonian Institution, and was most un-

fortunately delayed in its issue by the Government Printing Office; the first part, that relating to the Institution, having been published in the preceding year. The Museum Report forms an octavo volume of ix+458 pages, illustrated by 105 wood-cut plates.

649. "Annual Report of the Board of Regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the Institution to July, 1885. Part I." Owing to the change made by the Regents in the period of the Secretary's report, from the civil or calendar year to the fiscal year of the United States Government, this report of the condition of the Institution embraced only the first six months of the year 1885; or from January to June, inclusive. The volume contains the Journal of Proceedings of the Board of Regents, the report of the Executive Committee, the report of the Secretary of the Institution for six months, supplemented by the report on Exchanges, followed by the "General Appendix," in which is given a record of scientific progress for 1885, in astronomy, by William C. Winlock; with a list of astronomical observatories, by George H. Boehmer; in vulcanology and seismology, by Charles G. Rockwood; volcanic eruptions and earthquakes in Iceland within historic times (from the Icelandic of Th. Thoroddsen); geography, by J. King Goodrich; physics, by George F. Barker; chemistry, by H. Carrington Bolton; mineralogy, by Edward S. Dana; bibliography of North American invertebrate palæontology, by J. B. Marcou; zoology, by Theodore Gill; and anthropology, by Otis T. Mason; concluding with miscellaneous anthropological papers by correspondents; observations on stone-chipping, by George E. Sellers; copper implements from Bayfield, Wis., by Charles Whittlesey; ancient ruins in Ohio, by J. P. MacLean; a primitive store-house of the Creek Indians, by Charles C. Jones, jr.; shell-heaps and mounds in Florida, by James Shepard; ancient earth-works in China, by Mark Williams; plan for American ethnological investigation, by the late Henry R. Schoolcraft; index to the literature of Uranium, by H. Carrington Bolton; and price-list of the publications of the Smithsonian Institution. The whole forms an octavo volume of xviii + 996 pages, illustrated by 19 figures.

651. "Report of Prof. Spencer F. Baird, Secretary of the Smithsonian Institution, for the year 1885-'86." Octavo pamphlet of 83 pages.

The volume containing the above report, with its accompanying papers, together with the second part containing the report of the Museum, has not yet appeared. The usual concurrent resolution of Congress directing the printing of 16,000 copies of the reports for 1885-'86, failed to pass the House at its last session although it had passed the Senate in time. This has unfortunately delayed the issue of these volumes.

*Publications of the Bureau of Ethnology.*—"Fourth Annual Report of the Bureau of Ethnology, to the Smithsonian Institution, 1882-'83," by J. W. Powell, Director. The official report of the Director, occupy-

ing 39 pages (pp. xxv—lxiii), is accompanied by the following papers "Pictographs of the North American Indians, a preliminary paper," by Garrick Mallery; "Pottery of the Ancient Pueblos," by William H. Holmes; "Ancient Pottery of the Mississippi Valley," by William H. Holmes; "Origin and Development of Form and Ornament in Ceramic Art," by William H. Holmes; and "A Study of Pueblo Pottery, as illustrative of Zuni culture-growth," by Frank Hamilton Cushing. An imperial octavo volume of lxiii+532 pages, illustrated by 83 plates, of which 11 are colored, and 564 figures in the text.

#### INTERNATIONAL EXCHANGES.

Next in importance to the promotion of original research, and the propagation of its results in the Smithsonian series of publications, ranks the system of international exchanges, early established by this Institution, and continuously prosecuted by it until its operations have expanded beyond the unaided capabilities of its resources.

During the past fiscal year the receipts for foreign transmission amounted to 30,046 packages, weighing 83,902 pounds; the receipts for domestic distribution comprised 10,294 packages, weighing 34,861 pounds, and for Government exchanges the receipts were 21,600 packages, weighing 22,500 pounds, making the total of 61,940 packages received, weighing 141,263 pounds.

A comparison of the receipts for exchanges during the past fiscal year with those of the preceding year is given in the following table:

Receipts for transmission.	Fiscal year 1885-'86.		Fiscal year 1886-'87.	
	<i>Packages.</i>	<i>Pounds.</i>	<i>Packages.</i>	<i>Pounds.</i>
Foreign exchanges .....	26, 162	112, 901	30, 046	83, 902
Domestic exchanges .....	11, 702	39, 579	10, 294	34, 861
Government exchanges.....	56, 229	42, 924	21, 600	22, 500
Total .....	94, 093	195, 404	61, 940	141, 263

It is shown by the above that the receipts on account of Government exchanges for the past year have fallen off about one-half from those of the preceding year. This is mainly due to the diminished number of United States public documents printed during the "short session" of Congress.

During the past year two accessions have been made to the list of foreign Governments accepting the system of international exchange with the United States, namely, the Empire of Austria and the Republic of Peru.

*Transportation facilities.*—The liberal encouragement of the Smithsonian exchange operations afforded by the leading steamship com-



panies in granting the Institution free freight for its packages and boxes, which has existed for many years, still continues; and it is my pleasant duty annually to renew the expressions of grateful acknowledgment for the generous policy which has so greatly favored and advanced the system of exchanges. The following is a list of the companies favoring the Institution with the concessions mentioned, and to whose offices I desire, on behalf of the Regents, to return their hearty thanks.

Allan Steamship Company (A. Schumacher & Co., agents), Baltimore.

Anchor Steamship Line (Henderson & Brother, agents), New York.

Atlas Steamship Company (Pim, Forwood & Co., agents), New York.

Bailey, H. B., & Co., New York.

Bixby, Thomas E., & Co., Boston, Mass.

Borland, B. R., New York.

Boulton, Bliss & Dallett, New York.

Cameron, R. W., & Co., New York.

Compagnie Générale Transatlantique (L. de Bébian, agent), New York.

Cunard Royal Mail Steamship Line (Vernon H. Brown & Co., agents), New York.

Dennison, Thomas, New York.

Florio-Rubattino Line, New York.

Hamburg American Packet Company (Kunhardt & Co., agents), New York.

Inman Steamship Company, New York.

Merchants' Line of Steamers, New York.

Muñoz y Espriella, New York.

Murray, Ferris & Co., New York.

Netherlands American Steam Navigation Company (H. Cazaux, agent), New York.

New York and Brazil Steamship Company, New York.

New York and Mexico Steamship Company, New York.

North German Lloyd (agents, Oelrichs & Co., New York; A. Schumacher & Co., Baltimore).

Pacific Mail Steamship Company, New York.

Panama Railroad Company, New York.

Red Star Line (Peter Wright & Sons, agents), Philadelphia and New York.

White Cross Line of Antwerp (Funch, Edye & Co., agents), New York.

Wilson & Asmus, New York.

The thanks of the Institution are also due, and are hereby tendered, to the foreign ministers and consuls of the various Governments for their assistance in taking charge of the transmission of boxes to the countries which they respectively represent.

*Government Exchanges.*—The Smithsonian Institution, as is well known, has been made by law the agent of the United States Government for conducting the international exchanges of public official documents between it and foreign Governments. By joint resolution of

Congress (approved March 2, 1867), it was ordered that "fifty copies of all documents hereafter printed by order of either house of Congress, and fifty copies additional of all documents printed in excess of the usual number, together with fifty copies of each publication issued by any Department or Bureau of the Government, be placed at the disposal of the Joint Committee on the Library, who shall exchange the same through the agency of the Smithsonian Institution, for such works published in foreign countries, and especially by foreign Governments, as may be deemed by said committee an equivalent; said works to be deposited in the Library of Congress." And by supplemental joint resolution to carry the same into better effect (approved July 25, 1868), the Congressional Printer, whenever he shall be so directed by the Joint Committee on the Library, is required to print fifty copies in addition to the regular number of all documents hereafter printed by order of either house of Congress, or by order of any Department or Bureau of the Government, and whenever he shall be so directed by the Joint Committee on the Library, one hundred copies additional of all documents ordered to be printed in excess of the usual number; said fifty or one hundred copies to be delivered to the Librarian of Congress, to be exchanged under the direction of the Joint Committee on the Library, as provided by joint resolution approved March 2, 1867.

Since the international movement, commencing with the Paris convention of 1875, for promoting the free reciprocal exchange of public documents, there has been a growing interest in the subject manifested abroad. International conferences, for agreeing upon details, were held at Brussels, Belgium, in 1880, in 1883, and finally in 1886—March 15. There are now thirty-nine Governments in exchange with the United States, or, counting the duplicate sets sent to the Dominion of Canada (deposited at Ottawa and Toronto), there may be said to be forty foreign recipients. These are: The Argentine Confederation, Austria, Bavaria, Belgium, Brazil, Buenos Ayres, Canada, two sets (one for the parliamentary library at Ottawa, the other for the legislative library at Toronto), Chili, Colombia (United States of), Denmark, France, Germany, Great Britain, Greece, Hayti, Hungary, India, Italy, Japan, Mexico, Netherlands, New South Wales, New Zealand, Norway, Peru, Portugal, Prussia, Queensland, Russia, Saxony, South Australia, Spain, Sweden, Switzerland, Tasmania, Turkey, Venezuela, Victoria, and Württemberg.

*Assistance by the Government.*—In view of the great public and national services rendered by the exchange system, in the distribution of Government publications, and in the large accessions of valuable works annually made through its instrumentality to the Congressional Library, an appropriation has for some years past been granted by Congress in aid of this enterprise. And without this support the operations of the exchange service would be very seriously restricted. The usual appropriation of \$10,000 was granted to the Institution by the last Congress.

The total expenses of conducting the international exchanges, for the last two years, are shown in the following table:

Expenses of exchanges.	Fiscal year 1885-'86.	Fiscal year 1886-'87.
By the Institution .....	\$4,503.80	\$4,683.11
By appropriation .....	10,000.00	10,000.00
Total cost.....	14,503.80	14,683.11

*Insufficiency of the Government Exchanges.*—While the system of international exchanges inaugurated by the Smithsonian Institution is in a highly satisfactory condition, the same can not, unfortunately, be said of the system of *Government* exchanges intrusted to it. Notwithstanding the urgent and repeated efforts made by this Institution, it still fails to receive for foreign distribution a large portion of the United States official publications required for this service by law. Some more effectual legislation appears still necessary to secure the operation of existing statutes.

Still more unsatisfactory has been the condition of receipts from abroad in return for the valuable works actually sent from our Government. From the indifference of the agents of foreign Governments in the matter of securing and systematically appropriating their public documents to the service voluntarily undertaken by these Governments, the representation of such documents received by us has been meager in the extreme. The entire receipts from Europe during the past year have been contained in 5 boxes (with some books and pamphlets by mail), as against 163 Government boxes forwarded by the Institution. While it is recalled that when the officer in charge of our exchanges was sent abroad in 1884, on a tour of inspection and inquiry, the returns from 14 European Governments amounted for that year to 44 boxes and 160 packages of books, numbering in all about 7,000 volumes, the present inadequacy of foreign reciprocity becomes painfully apparent. I am constrained to here repeat the earnest recommendation made by the diligent librarian of the Congressional Library, directed to this matter. In his report for 1885 Mr. Spofford well remarks:

“The experience of years has amply proved the impossibility of securing any complete or adequate return from foreign Governments for the full and costly series of American Government publications so long furnished them, without direct and persistent effort, through an agency upon the ground furnished with adequate credentials, to attend personally to the whole business. One of the chief benefits of the initial effort already made has been the discovery of the practical obstacles in the way of a thoroughly successful system of exchanges. These, it is believed, could be removed by following up the work with each Government, while if neglected or left to the very uncertain medium of cor-



respondence the United States will continue to reap very inadequate returns for our publications sent abroad. It is recommended that the Joint Committee on the Library consider the expediency of providing an appropriation to defray the necessary expenses of an agent of international exchanges, to be sent abroad for a term of at least six months during the present year.

"It is also recommended that the act directing the printing of fifty copies of each publication ordered by any Department or Bureau, to be devoted to international exchanges, be so amended as to render its provisions more effective."

The success of the experiment made by us in 1884 would appear to show that only the employment of an experienced agent of the Institution, in the work of visiting foreign countries and personally securing from their authorities the due transmission to our Government of public documents as soon as published, is likely to be effective in obtaining the desired result.

#### LIBRARY.

The fact should constantly be borne in mind that the distribution of the publications of the Institution secures in return a large amount of valuable material for the Library of Congress. Whatever cost, therefore, there may be to our Government for Smithsonian or Museum reports, etc., it is many times repaid by the exchanges received, in addition to which the returns for the many volumes of publications printed entirely at the expense of the Smithsonian fund find the same depository. By the joint resolutions of 1867 and 1868, above referred to, the "works published in foreign countries, and especially by foreign Governments," that may be obtained by our international exchanges, are directed "to be deposited in the Library of Congress." This great national institution thus becomes the beneficiary of this branch of the service, and it is a matter of public interest that such returns should be placed on their broadest basis.

The following is a statement of the books, maps, and charts received by the Smithsonian Institution from July 1, 1886, to June 30, 1887:

#### Volumes:

Octavo or smaller .....	1, 664	
Quarto or larger .....	417	
	<hr/>	2, 081

#### Parts of volumes:

Octavo or smaller .....	5, 034	
Quarto or larger .....	5, 930	
	<hr/>	10, 964

#### Pamphlets:

Octavo or smaller .....	2, 785	
Quarto or larger .....	426	
	<hr/>	3, 211

Maps.....		291
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Total.....		<hr/> <hr/> 16, 547
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The following table shows the number of volumes, pamphlets, etc., received by the Institution during the past two years; all of which were transferred to the Library of Congress, excepting a small number transferred to the library of the National Museum:

*Deposit of books, etc., in the Library of Congress by the Smithsonian Institution, 1885-'87.*

Fiscal years.	Volumes.	Parts.	Pamphlets.	Maps.	Total.
1885-'86.....	1,938	11,021	2,928	379	16,266
1886-'87.....	2,081	10,964	3,211	291	16,547
Total .....	4,019	21,985	6,139	670	32,813

### U. S. NATIONAL MUSEUM.

The National Museum, though supported by Government appropriations, has since 1846 been under the direction of the Institution. Its rapid growth during the last few years has shown how impossible it would be for the Smithsonian Institution to adequately maintain it, even by the devotion of its entire resources to the task. Indeed, the spacious building so recently erected by the Government for its accommodation is already quite insufficient to display its accumulation of valuable material, and unless a due provision be early made for the erection of additional buildings (as urgently asked for in my report for 1883, and in subsequent reports) there will be a serious hinderance to the proper administration of the establishment in the insufficiency of space which can be allowed to its several scientific departments.

In the report of the Museum for 1884 (at page 20), the number of specimens is estimated at 1,471,000; this number is now increased by more than a million, and it is evidently a matter of great importance that some means of storing and exhibiting this vast quantity of incoming material should be provided without delay. The growth of this Museum has been exceedingly rapid. Until the beginning of this decade there was only 1 curator with a few "assistants." At the present time there are 31. regularly-organized departments and sections under the care of 26 curators and numerous assistant curators and aids. Only 9 of the curators receive salaries from the Museum appropriations. Of the remaining 17, 4 are detailed from the U. S. Fish Commission, 2 from U. S. Army, 1 from U. S. Navy, 5 from the U. S. Geological Survey, and 1 from the Bureau of Ethnology. Prof. O. C. Marsh has been appointed honorary curator of the department of vertebrate fossils, and Mr. S. R. Koehler, of Roxbury, Mass., has accepted a commission as acting curator of the section of graphic arts.

There have been no important changes in the administrative staff, a classification of which is given in full in the report for 1885-1886.

It is estimated that there are now in the Museum 2,592,732 "lots" of specimens, an increase of 1,121,732 during the last two and a half years. The catalogues of the various departments show that in the aggregate 36,595 entries of accession "lots" have been made during the year. In speaking of the accessions to the Museum, I desire to present the cordial thanks of the Smithsonian Institution to the various Departments and Bureaus of the Government through whose valuable co-operation a great deal of interesting material has been received.

The increased popularity of the Museum is plainly evidenced by the fact that during the year it has been visited by 216,562 persons, while 98,592 visitors were registered in the Smithsonian building, giving a total of 315,114 visitors to both buildings during the year. This is an increase of 51,929 over the number recorded for the last fiscal year.

Mr. A. H. Clark has been appointed editor of the Proceedings and Bulletins in place of Dr. T. H. Bean, who for many years has carried on this work with great ability. This change was made at Dr. Bean's request, since the demands on his time as curator of fishes, left very little opportunity for him to attend to editorial work. During the year the Museum report for 1884 was issued, and the manuscripts for both the 1885 and 1886 reports are now in the hands of the printer. Vol. VIII of the "Proceedings of the National Museum" was issued in October, and the signatures of Vol. IX are all in print. In addition 6 signatures of Vol. X were distributed before the close of the fiscal year. Bulletin 31, "Synopsis of the North America Syrphidæ," by Dr. Samuel M. Williston, appeared in May. Bulletin 32, "Catalogue of the Batrachia and Reptiles of Central America and Mexico," by Prof. E. D. Cope, is now in type. The manuscript for Bulletin 33, "Catalogue of Minerals and Synonyms," by Mr. Thomas Egleston, as well as that for Bulletin 34, "Catalogue of the Batrachia and Reptiles of North America," by Prof. E. D. Cope, has gone to the Government Printing Office. A bibliography of papers published by officers of the Museum and by co-operators in Museum work is included in the report of the assistant secretary. This embraces 345 titles by 84 authors, 32 of whom are officially connected with the Museum.

In the library, the total number of publications received during the year, exclusive of regular periodicals, was 1,511. The most valuable contributions to the library were those made by the Secretary of the Institution.

There were received 2,055 forms of labels, from the Government Printing Office, each form containing 24 copies, 12 of which are printed on card-board and 12 on paper.

As in previous years, several students in various branches of natural history have enjoyed the privilege of access to the collections in which they were especially interested. Courtesies of this kind have been extended notably by the departments of birds, insects, mollusks, marine



invertebrates, minerals, mammals, ethnology, and fishes. Instruction in taxidermy and photography has been given to several applicants.

The regular Saturday lectures, 12 in number, were given in the lecture hall between March 12 and May 7. The national convention of Superintendents of Schools (March 15-17) and the Dental Association (July 27-29) held their meetings in the same hall. The Biological Society of Washington also used this room for their regular fortnightly meetings during the winter.

The Museum preparators have been kept constantly employed during the year. The chief taxidermist was sent by this Institution to Montana for the purpose of obtaining skins and skeletons of American bison, and the results of this expedition were successful. The details of the work accomplished in the various preparators' shops will be found in the report of the assistant secretary, on the condition of the Museum.

The work accomplished in the scientific departments is described at length in the reports of the curators, given in the Museum Report, which forms Part II of the Smithsonian Report. As this work is briefly reviewed by the Assistant Secretary in the said Museum report it is unnecessary to enlarge upon it here.

It seems proper that I should here pay a tribute of respect to a departed collaborator—Capt. Hubbard C. Chester—who, as connected with the U. S. Fish Commission service, has contributed to the accessions of the Museum. Captain Chester was born at Groton, Conn., July 6, 1835. Devoted to a sea-faring life from his earliest manhood, he joined the ship *Leander* in 1857, under the command of his uncle, Capt. Brad-dock Chester, on a whaling voyage. In 1860 he sailed in the schooner *Cornelia* to the southern Indian Ocean in pursuit of elephant seals. In 1864, as mate of the whaling vessel, *Monticello*, he made a voyage to Hudson Bay. In 1871, as mate of the ill-fated *Polaris*, under command of Capt. Charles F. Hall, he joined in the Arctic expedition; and it was to his skill and courage that the survivors of this expedition owed their preservation. In 1874, Captain Chester attached himself to the Fish Commission, in which service he remained during his life. In 1883 he superintended the packing of the collections sent by the U. S. Commission to the International Fisheries Exhibition at London, assisted in the installation of the exhibition at London, and also in repacking the exhibit for return to this country. In 1885 he was made superintendent of the new station at Wood's Holl.

After an illness primarily induced by his exposures he died at his home in Noank, Conn., July 19, 1886. His varied services—faithfully rendered—inspired all who knew him with a high appreciation of his abilities and a strong regard for his manly worth.

## BUREAU OF ETHNOLOGY.

The prosecution of ethnologic researches among the North American Indians, under the direction of the Secretary of the Smithsonian Institution and in compliance with acts of Congress, was continued during the year 1886-'87, under the charge of Maj. J. W. Powell, who has furnished the following account of operations.

The work of the year may be conveniently reported upon under the two general heads of field work and office work.

*1. Field work.*

The field work of the year is divided into (1) mound explorations and (2) general field studies, embracing those relating to social customs, institutions, linguistics, and other divisions of anthropology.

*Mound explorations.*—The work of exploring the mounds of the eastern United States was, as in previous years, under the charge of Prof. Cyrus Thomas.

Although Professor Thomas and his assistants have devoted a large portion of the year to the study of the collections made in the division of mound exploration and to the preparation of a report of its operations for the past five years, yet some field work of importance has been done.

Professor Thomas, in person, has examined the more important ancient works of New York and Ohio. He has given special attention to the latter, with a view of determining where new and more accurate descriptions, surveys, and illustrations are necessary. It was found requisite to undertake a careful re-survey and description of a number of the well-known works in Ohio. This re-examination, which is still in progress, is deemed the more necessary in view of the light shed on the origin and use of these monuments by the explorations which have been carried on in West Virginia, western North Carolina, and eastern Tennessee.

Mr. J. P. Rogan continued his work as assistant until the close of November, when he voluntarily resigned his position to enter upon other engagements. A portion of his time during the first month was occupied in arranging and preparing for shipment the collection purchased of Mrs. McGlashan, in Savannah, Ga. The rest of his time was employed in exploring mounds along the upper Savannah River in Georgia and South Carolina and along the lower Yazoo River in Mississippi.

Mr. J. W. Emmert continued to act as field assistant until the end of February, when the field work closed. His labors, with the exception of a short visit to central New York, were confined to east Tennessee, chiefly Blount, Monroe, and Loudon Counties, where numerous extensive and very interesting groups are found in the section formerly occupied by the Cherokee. Professor Thomas has thought it necessary to devote

considerable attention to the ancient works of that region, as it is probable that there and in western North Carolina is to be found the key that will materially assist in solving the problem of the singular works of Ohio. The results of these explorations are of unusual interest, independent of their supposed bearing on the Ohio mounds.

Mr. J. D. Middleton, who has been a constant assistant since the organization of the division, after completing some investigations begun in southern Illinois, visited western Kentucky for the purpose of investigating the works of that section, but was soon afterwards called to Washington to take part in the office work. During the month of June he visited and made a thorough survey of the extensive group of works near Charleston, West Va., of which Colonel Norris had made a partial exploration, the latter having been prevented from completing it by the sickness which immediately preceded his death. During the same month Mr. Middleton commenced the survey of the Ohio works before alluded to, securing some valuable results in the short time before the close of the year.

Mr. Gerard Fowke was also engaged for a short time in field work in western Pennsylvania, Ohio, and Kentucky, but was called early in autumn to Washington to assist in office work.

*General field studies.*—During October and December Mr. Albert S. Gatschet was engaged in gathering historic and linguistic data in Louisiana, Texas, and the portion of Mexico adjoining the Rio Grande, this region containing the remnants of a number of tribes of whose language and linguistic affinity practically nothing is known. After a long search Mr. Gatschet found a small settlement of Biloxi Indians at Indian Creek, 5 or 6 miles west of Lecompte, Rapides Parish, La., where they gain a livelihood as day laborers. Most of them speak English more than their native tongue. In fact about two-thirds of the thirty-two survivors speak English only. The vocabulary obtained by him discloses the interesting fact that the Biloxi belong to the Siouan linguistic family.

Mr. Gatschet heard of about twenty-five of the Tunica tribe still living in their old homes on the Marksville Prairie, Avoyelles Parish, La. An excellent vocabulary was obtained of their language at Lecompte, La., and a careful comparison of this with other Indian languages shows that the Tunica is related to none, but represents a distinct linguistic family.

He was unable to collect any information in regard to the Karankawa tribe, concerning which little is known except that they lived upon the Texan coast near Lavacca Bay.

Leaving Laredo County, Texas, he visited Camargo in Tamaulipas, Mexico, finding near San Miguel the remnants of the Comecrudo tribe, or, as they are called by the whites, Carrizos. Only the older men and women still remember their language. The full-blood Comecrudos seen



by Mr. Gatschet were tall and thin, some of them with fairer complexions than the Mexicans. Subsequently the Cotoname language, formerly spoken in the same district, was studied and found to be a distantly related dialect of Comecrudo. Both of them belong to the Coahuiltecan family. From the Comecrudo Mr. Gatschet obtained the names of a number of extinct tribes who formerly lived in their vicinity, but of whom no representatives are left. These are the Casas Chiquitas, Tejones (or "raccoons"), Pintos or Pakawás, Miakkan, Cartujanos. Mr. Gatschet next visited the Tlaskaltecs Indians, who live in the city of Saltillo. Of these Indians about 200 still speak their own language, which is almost identical with the Aztec, although largely mixed with Spanish.

Mr. Josiah Curtin was engaged from the middle of March to June 1 in completing investigations begun the previous year into the history, myths, and language of the Iroquois Indians at Versailles, Cattaraugus County, N. Y. The material secured by him is of great interest and value.

## 2. *Office work.*

The Director, Maj. J. W. Powell, has continued the work of the linguistic classification of the Indian tribes in North America north of Mexico, and in connection with it is preparing a map upon a linguistic basis showing the original habitat of the tribes. The work is now so far advanced that it is expected to be ready for the printer before January next. It will form a part of the seventh annual report.

As previously stated, Professor Thomas has devoted much of his time during the year to the study of the collections made, and in preparing for publication the account of field work performed by himself and his assistants. That account will form the first volume of his final report, and will consist wholly of descriptions, plans, and figures of the ancient works examined, narrative and speculation being entirely excluded. The report will be ready for publication so soon as the illustrations shall be prepared and some verifications and supplemental surveys now being made, shall be completed.

The second volume, which will be devoted to the geographic distribution of the various types of mounds, archæologic maps and charts, and a general discussion of the various forms and types of ancient works, is well under way. The preliminary list of the various monuments known, and of the localities where they are found, together with references to the works and periodicals in which they are mentioned, which Mrs. V. L. Thomas, in addition to her other duties as secretary to Mr. Thomas, has been engaged upon for nearly three years, is now completed, and is being used in the preparation of maps. It will form a part of the second volume.

Mr. Middleton's office work has consisted entirely in the preparation of maps, charts, and diagrams. These are of two classes: (1) Those made entirely from original surveys, which constitute the larger portion,

and (2) the archæological maps of States and districts, showing the distribution of given types, which are made from all the data obtainable, including additions and verifications made by the mound exploration division of the Bureau.

Mr. Gerard Fowke, in addition to assisting in the preparation of the report on the field work which is to constitute the first volume, has made a study of the stone articles of the collection, and Mr. H. L. Reynolds jr. has made a study of the copper articles collected, both with a view of preparing papers for the third volume of the report. The paper by Mr. Reynolds is nearly completed.

Mr. Pilling continued his bibliographic studies during the year, with the intention of completing for the press his bibliography of North American languages. After consultation with the Director and a number of gentlemen well informed on the subject, it was concluded that the wants of students in this branch of ethnology would be better subserved were the material to be issued in separate bibliographies, each devoted to one of the great linguistic stocks of North America. The first to be issued related to the Eskimo, forming a pamphlet of 116 pages. The experiment proved successful, and Mr. Pilling continued the preparation of the separates. Late in the fiscal year the copy of the bibliography of the Siouan family was sent to the Public Printer. It is Mr. Pilling's intention to continue this work by preparing a bibliography of each of the linguistic groups as fast as opportunity will permit.

Mr. Frank H. Cushing continued work, so far as his health permitted, upon his Zuñi material until the middle of December. At that time he gave up office work and left for Arizona and New Mexico, intending to devote himself for a season to the examination of the ruins of that region with the view of obtaining material of collateral interest in connection with his Zuñi studies as well as in hope of restoring his impaired health.

Mr. Charles C. Royce, although no longer officially connected with the Bureau, has devoted much time during the past year to the completion of his work upon the former title of Indian tribes to lands within the United States and the methods of securing their relinquishment. This work, delayed by Mr. Royce's resignation from the Bureau force, is now nearly completed and will soon be ready for publication.

Dr. H. C. Yarrow has continued the preparation of the material for his final report upon the mortuary customs of the North American Indians. The collection of data from various sources has been practically completed, and nothing now remains but the classification and elaboration of the great amount of material into its final form, which work is in an advanced state.

Mr. William H. Holmes has continued the archæologic work begun in preceding years, utilizing such portions of his time as were not absorbed in work pertaining to the Geological Survey. A paper upon the antiquities of Chiriqui and one upon textile art in its relation to

form and ornament, prepared for the sixth annual report, were completed and proofs were read. During the year work was begun upon a review of the ceramic art of Mexico. A special paper, with 20 illustrations, upon a remarkable family of spurious antiquities belonging to that country, was prepared and turned over to the Smithsonian Institution for publication. In addition, a preliminary study of the prehistoric textile fabrics of Peru was begun, and a short paper, with numerous illustrations, was written.

Mr. Holmes has general charge of the miscellaneous archæologic and ethnologic collections of the Bureau, and reports that Dr. Cyrus Thomas, Mr. James Stevenson, and other authorized agents of the Bureau have obtained collections of articles from the mounds of the Mississippi Valley and from the ruins of the Pueblo country. A number of interesting articles have also been acquired by donation. Capt. J. G. Bourke, of the U. S. Army, presented a series of vases and other ceremonial objects obtained from cliff dwellings and caves in the Pueblo country; Mr. J. B. Stearns, of Short Hills, made a few additions to his already valuable donations of relics from the ancient graves of Chiriqui, Colombia; and Mr. J. N. Macomb presented a number of fragments of earthenware from Graham County, N. C. Some important accessions have been made by purchase. A large collection of pottery, textile fabrics, and other articles from the graves of Peru was obtained from Mr. William E. Curtis; a series of ancient and modern vessels of clay and numerous articles of other classes from Chihuahua, Mexico, were acquired through the agency of Dr. E. Palmer; a small set of handsome vases of the ancient white ware of New Mexico was acquired by purchase from Mr. C. M. Landon, of Lawrence, Kans., and several handsome vases from various parts of Mexico were obtained from Dr. Eugene Boban.

As in former years, Mr. Holmes has superintended the preparation of drawings and engravings for the Bureau publications. The number of illustrations prepared during the year amounted to 650.

During the fiscal year Mr. Victor Mindeleff has been engaged in the preparation of a report on the architecture of the Tusayan and Cibola groups of pueblos, which is nearly ready for publication. This report will contain a description of the topography and climate of the region, in illustration of the influence of environment upon the development of the pueblo type of architecture. It will also contain a traditionary account of the Tusayan pueblos and of their separate clans or phratries. A description in detail of the Tusayan group will treat of the relative position of the villages and such ruins as are connected traditionally or historically with them. A comparative study is also made between the Tusayan and Cibola groups and between them and certain well preserved ruins in regard to constructive details, by which means the comparatively advanced type of the modern pueblo architecture is clearly established. Maps of the groups discussed and of the topography of



the country and ground plans of houses and apartments will illustrate the report and give effect to the descriptions and discussion.

Mr. Cosmos Mindeleff devoted the early part of the fiscal year to the preparation of a report upon the exhibits of the Bureau of Ethnology and the Geological Survey at the Cincinnati Industrial Exposition, 1884; the Southern Exposition at Louisville, 1884; and the Industrial and Cotton Centennial Exposition at New Orleans, 1884-'85. The report includes a descriptive catalogue of the various exhibits. As these consisted largely of models, and as the locality or object represented by each model was described in detail, the report was lengthy. It was finished in October and transmitted to the commissioner representing the Interior Department. During the remainder of the year the portion of time which Mr. Mindeleff was able to devote to office work was employed in assisting Mr. Victor Mindeleff in the preparation of a preliminary report on the architecture of Zuñi and Tusayan (Moki). The portion assigned to him consists of an introductory chapter, which will include a review of the literature of the subject and a chapter devoted to traditionary history of Tusayan, from material collected by Mr. A. M. Stephen, of Keam's Cañon, Ariz.

The modeling room has remained in charge of Mr. Cosmos Mindeleff. The preparation of a duplicate series of the models made in the past few years and now deposited in the National Museum was continued, a large portion of the time being given to that work. During the year the following models were added to this series, which now consists of eighteen models: (1) Relief map of the high plateaus of southern Utah; (2) model of Leadville and vicinity; (3) model of Shimopavi, Tusayan, Arizona; (4) model of Etowah mound, Georgia; (5) model of Mishongvi; (6) model of Zuñi; (7) model of Penasco Blanco; (8) models of Etruscan graves (series to illustrate Etruscan graves, from material furnished by Mr. Thomas Wilson).

During 1886, and continuously to the end of the fiscal year, Mr. E. W. Nelson has devoted much time to preparing a report upon the Eskimo of northern Alaska, for which his note-books and large collections obtained in that region furnish ample material. During 1886 the vocabularies, taken from twelve Eskimo dialects for use in Arctic Alaska, were arranged in the form of an English-Eskimo and Eskimo-English dictionary. These dictionaries, with notes upon the alphabet and grammar, will form one part of his report. The other part, upon which he is at work at present, will consist of chapters upon various phases of Eskimo life and customs in Alaska, and will be illustrated by photographs taken by him on the spot, and by specimens collected during his extended journeys in that region. Mr. Nelson's notes upon Eskimo legends, festivals, and other customs will form an important contribution.

Mr. Lucien M. Turner is also engaged in the preparation of a similar report upon the Eskimo, in the form of a descriptive catalogue of the

large amount of material collected by him during a residence of several years at Saint Michaels and in the Aleutian Islands. When these two reports shall be completed the amount of accurate information concerning the singular people to whom they relate will be materially increased.

Mr. H. W. Henshaw has continued in charge of the work upon the synonymy of the Indian tribes of the United States, which was alluded to in some detail in the report of last year. This work has been suspended for a period, and Mr. Henshaw has assisted the Director in the preparation of a linguistic map of the region north of Mexico, and in the classification of the Indian tribes, a work which properly precedes and forms the basis of the volume on synonymy.

Col. Garrick Mallery was steadily occupied during the year in the work of the synonymy of the Indian tribes, his special field being the Iroquoian and Algonquian linguistic stocks, and his particular responsibility being the careful study of all the literature on the subject in the French language. He also, when time allowed, continued researches in and correspondence concerning sign language and pictographs.

Mr. James Mooney also has been occupied during the entire year in conjunction with Colonel Mallery in that portion of the work of the Indian synonymy relating to the Algonquian and Iroquoian families.

Mr. J. N. B. Hewitt has continued the work left unfinished by Mrs. Erminnie Smith. During the year he has been engaged in recording, translating, and tracing the derivation of Tuscarora-English words for a dictionary. He has thus far recorded about 8,000 words.

Mr. Albert S. Gatschet has devoted almost the entire year to the synonymy of Indian tribes and has practically completed the section assigned to him, viz, the tribes of the southeastern United States.

Rev. J. Owen Dorsey continued his work on the Indian synonymy cards of the Siouan, Caddoan, Athabasean, Kusan, Yakonan, and Takilman linguistic stocks. He resumed his preparation of the dictionary cards for Contributions to North American Ethnology, Vol. VI, Part II, and in connection therewith found it necessary to elaborate his additional Čegiha texts, consisting of more than two hundred and fifty epistles, besides ten or more myths gained since 1880. This work was interrupted in March, 1887, when he was obliged to undertake the arrangement of a new collection of Teton texts for publication. Mr. George Bushotter, a Dakota Indian who speaks the Teton dialect, was employed by the Director, from March 23, for the purpose of recording for future use of the Bureau some of the Teton myths and legends in the original. One hundred of these texts were thus written, and it devolved on Mr. Dorsey to prepare the interlinear translations of the texts, critical and explanatory notes, and other necessary linguistic material as dictated by Mr. Bushotter. Besides writing the texts in the Teton dialect, Mr. Bushotter has been able to furnish numerous sketches as illustrations, all of which have been drawn and colored ac-

ording to Indian ideas. His collection is the most extensive that has been gained by any collector among the tribes of the Siouan family, and it is the first one contributed by an Indian.

Dr. W. J. Hoffman and Mr. Josiah Curtin, as heretofore, have continued to assist in the work of the synonymy of the Indian tribes.

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[In consequence of severe illness, Professor Baird had not extended and completed his report, as he doubtless had contemplated; and the Acting Secretary respectfully submits the same, without feeling called upon for further comment.]

WASHINGTON, *December 1*, 1887.





## APPENDIX TO THE SECRETARY'S REPORT.

### REPORT ON SMITHSONIAN EXCHANGES FOR THE YEAR ENDING JUNE 30, 1887.

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By GEO. H. BOEHMER.

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#### I. SMITHSONIAN EXCHANGES.

*Personnel and duties.*—In prosecuting the plans recommended for the execution of the duties devolving on the exchange division, the services of some of the clerks became superfluous, and on the 1st of April, 1887, they were assigned to duty in other departments of the Institution.

The assistants to the exchange clerk now are:

1. Mr. F. V. Berry, who receives, receipts for, acknowledges by postal card, verifies, and journalizes all incoming exchanges; who ships all foreign and government exchanges, and writes out the shipping orders and announcements to the transportation companies and distributing agents.

2. Mr. H. A. Parker, who assists Mr. Berry, and in addition keeps a card catalogue of the titles of official publications received from the Public Printer as provided for by law.

3. Mr. C. W. Shoemaker, who records all exchange transactions by (a) entering in day-book; (b) posting on ledger cards; (c) making out invoices; (d) recording acknowledgments; (e) entering letters.

4. Mr. A. F. Adams, who assists Mr. Shoemaker in the execution of the above duties.

5. Mr. M. A. Tolson, who attends to the shipping of packages for domestic distribution, and in addition assists Mr. Berry in shipping foreign exchanges.

My own regular duties are:

(a) The supervising of the service in all its branches.

(b) The receiving of all exchange letters, acting on the same according to instructions, and preparing replies or memoranda for replies, by the corresponding clerk.

(c) The translation of foreign letters and documents.

(d) The verifying of requests from abroad, for Smithsonian publications, including the issuing of orders for the same and the keeping of an account of every Smithsonian publication sent abroad. A quarterly abstract of this account is submitted to the Chief Clerk.

(e) The preparation of a card catalogue, from the old records, showing the distribution of the volumes of Contributions to Knowledge and of the Miscellaneous Collections since the establishment of the Institution.

(f) The preparation of a scientists' directory.

(g) The preparation, for ready reference, of bibliographical information relating to the titles of the publications of foreign establishments in correspondence with the Institution.

(h) The execution of any work assigned by the Secretary, the Assistant secretaries, and the Chief Clerk.

A very important duty, under this last head, intrusted to me by Professor Langley, the acting and assistant secretary, was that of collecting and arranging all the information relating to the proposed plan for the increase of the Smithsonian library, and to report on the results of the inquiry.

The report submitted on the subject represents two divisions: I. Inquiry. II. Result.

The first division, that of inquiry, is again subdivided into two sections, of which the first shows, in brief, abstracts of all transactions of consequence connected with the scheme, to the number of two hundred, including the report, and representing, as recorded in full in the journal, 475 folio pages of manuscript. Part 2 represents a list of persons addressed on the subject, by circular letter or otherwise, and their respective replies, as indicated by the number corresponding to each document in the journal. Three hundred letters were written and 174 replies received, as follows:

Letters to curators of the National Museum .....	26
Replies .....	22
Letters to others.....	274
Replies .....	152

Section 2, or part 3, of the report represents the results of the replies received, in the form of a geographical arrangement, based on the existing list of foreign correspondents, of the titles obtained, together with the number of recommendations on each case. Of this the following condensed statement is presented:



Country.	Titles.	Refer-ences.	Country.	Titles.	Refer-ences.
AFRICA.			Victoria .....	5	6
Algeria .....	3	4	New Zealand .....	7	12
Cape Colony .....	1	1	EUROPE.		
Egypt .....	2	4	Austria Hungary .....	124	163
AMERICA.			Belgium .....	66	105
British .....	44	61	Denmark .....	14	20
United States .....	866	1,445	France .....	439	695
Mexico .....	8	10	Germany .....	669	993
Argentine Republic .....	11	16	Great Britain and Ireland .....	439	809
Brazil .....	9	11	Greece .....	4	9
Chili .....	4	4	Iceland .....	1	2
Colombia .....	1	1	Italy .....	154	217
Costa Rica .....	2	2	Netherlands .....	37	49
Ecuador .....	1	1	Norway .....	19	31
Venezuela .....	1	1	Portugal .....	12	20
ASIA.			Roumania .....	2	2
China .....	3	4	Russia .....	52	74
India .....	23	31	Servia .....	1	1
Japan .....	9	13	Spain .....	35	38
Java .....	5	8	Sweden .....	26	44
AUSTRALASIA.			Switzerland .....	51	66
New South Wales .....	7	13	Turkey .....	1	1
Queensland .....	1	1	Books .....	33	34
South Australia .....	1	1	Books in west room of Patent Office library (Document No. 198) ap- proximate .....	400	700
Tasmania .....	1	2	Total .....	3,594	5,730

A subject arrangement of all the titles obtained, in form of a card catalogue, is in course of preparation, and of this I beg to give a summary, showing the number of recommendations received on any of the branches of science designated in the original plan:

Subject.	Refer-ences.	Subject.	Refer-ences.
Agriculture .....	72	Costumes .....	3
Animal products and fisheries .....	51	Education .....	192
Archæology .....	6	Education of deaf and dumb .....	2
Archæology and art .....	90	Electricity .....	60
Architecture .....	10	Electrical engineering .....	35
Architecture and engineering .....	7	Electrotyping .....	6
Art .....	46	Engineering .....	59
Assyriology .....	26	Engineering and industries .....	528
Astronomy .....	30	Ethics .....	3
Botany .....	380	Ethnology .....	160
Brewing and distillations .....	2	Fencing .....	7
Birds .....	49	Gas .....	2
Bridge engineering .....	12	General science .....	9
Chemistry .....	105	Geography .....	340
Chemistry and physics .....	14	Graphic arts .....	16
Civil engineering .....	54	Historical science .....	82
Classical philology .....	1	History .....	27
Comparative anatomy .....	35	Industries .....	12

Subject.	Refer- ences.	Subject.	Refer- ences.
Insects.....	86	Numismatics.....	13
Instruments of precision.....	2	Ordnance.....	15
International law.....	6	Paper and printing.....	4
Invertebrate palæontology.....	119	Patents.....	11
Librarian's art and bibliography.....	150	Pedagogy.....	33
Literature, ancient and classical.....	72	Philology.....	16
Lithology.....	68	Photography.....	13
Logic.....	7	Physics.....	14
Machine construction.....	16	Political economy.....	3
Mammals.....	58	Political science.....	41
Marine invertebrates.....	50	Prime motors.....	7
Mathematics.....	16	Psychology.....	28
Mathematics and algebra.....	27	Railroad.....	7
Mechanical engineering.....	18	Reptiles.....	10
Mechanics and machinery.....	5	Sanitary engineering.....	8
Medicine and surgery.....	7	Social science.....	24
Metallurgy.....	24	Sport.....	5
Marine engineering.....	10	Statistics.....	80
Metaphysics and psychology.....	13	Telegraphy.....	1
Microscopy.....	19	Textile and dyeing.....	3
Military engineering.....	17	Theology.....	170
Military sciences.....	36	Trade.....	17
Mineralogy.....	50	Wind engines.....	4
Mineralogy, chemistry, and physics.....	39	Johns Hopkins University ex- change list.....	805
Mining.....	101	Patent Office Library, west room, list of books.....	700
Mining and metallurgy.....	3		
Music.....	8		
Naval architecture.....	28		5,756
Naval arts.....	113	Less duplication of titles.....	26
Naval engineering.....	12		
Naval machinery.....	11	Total.....	5,730

As shown by the geographical arrangement, 3,594 distinct titles, representing 5,730 references, were reported by the collaborators, and it was part of my instructions to ascertain how many of these were already correspondents of the Institution.

Subtracting from the number of titles the 400 approximated from the unclassified list of books in the west room of the Patent Office Library, and the 866 published in the United States, 2,328 foreign serials remain, and of these 792, or 34 per cent., occur in our list of foreign correspondents, which number, however, will be increased to some extent by the correction of titles, given in many cases but very indistinctly, and by the assignment to the proper society on the list of correspondents of magazines and journals properly to be designated under the name of the society; and it is believed that upon that correction nearly one-half of all the foreign titles given may be considered as correspondents of the Institution.

I beg here to state that owing to the press of routine duties all the work connected with the library inquiry has been performed by me in my leisure hours.

*Work performed.*—During the past year 61,940 packages, representing a weight of 141,263 pounds, were received. Of these 10,294 were

for domestic distribution, and these were sent out through the United States Post-Office. The remainder was for foreign and Government distribution, requiring 692 packing-boxes with a bulk of 4,122 cubic feet.

The total number of entries were, for domestic exchanges 20,590, and for the foreign branch 51,917 entries.

The ledger shows 9,561 running accounts, of which 7,396 are with correspondents abroad and 2,165 with domestic establishments and individuals.

For foreign transmission 15,298 invoices required to be written, of which 12,430 were returned properly receipted, and which had to be credited on the respective accounts. Of domestic invoices 4,924 were returned by consignees and entered.

Letters received during the year 1,131, and 1,217 were written.

In the following table I beg to give a detailed statement of the amount of work performed during each month of the year:

*Work performed during the fiscal year 1886-'87.*

	July.	August.	September.	October.	November.	December.
Packages received :						
Number .....	3,571	6,183	3,761	3,425	11,026	4,339
Weight .....	19,892	14,258	10,222	9,012	15,504	11,887
Entries made :						
Foreign .....	3,168	8,812	4,108	2,582	1,828	5,064
Domestic .....	1,974	1,800	1,840	2,838	2,148	1,314
Ledger cards :						
Foreign .....						
Domestic .....						
Domestic packages sent .....	97	900	920	1,418	1,074	657
Invoices written .....	1,126	1,398	1,124	1,048	467	1,880
Cases shipped abroad .....	103	65	42	30	58	49
Receipts recorded :						
Foreign .....	1,020	1,018	-----	1,226	1,230	4,474
Domestic .....	596	158	448	501	500	882
Letters recorded .....	97	105	82	53	96	102
Letters written .....	131	38	25	14	103	30

	January.	February.	March.	April.	May.	June.	Total for year.
Packages received :							
Number .....	3,505	2,754	12,238	2,531	3,183	5,124	61,940
Weight .....	8,646	7,393	15,711	9,512	11,322	17,204	141,263
Entries made :							
Foreign .....	4,642	3,430	2,706	2,684	3,712	9,181	51,917
Domestic .....	1,722	1,210	1,598	2,326	618	1,202	20,590
Ledger cards :							
Foreign .....							7,396
Domestic .....							2,165
Domestic packages sent .....	861	605	799	1,163	309	601	10,294
Invoices written .....	959	551	897	837	1,464	3,537	15,288
Cases shipped abroad ..	38	29	71	21	91	95	692
Receipts recorded :							
Foreign .....	874	189	296	852	673	573	12,430
Domestic .....	381	84	196	620	255	303	4,924
Letters recorded .....	101	81	96	108	132	78	1,131
Letters written .....	88	159	195	141	156	137	1,217



*Transportation companies.*—The only change which has taken place in the relations of the Institution to the transportation companies extending the privilege of free freight on all Smithsonian exchanges was caused by the dissolution of the Monarch Line, plying between London and New York. Satisfactory arrangements, however, have been made with Messrs. Barber & Co., of New York, to forward the cases to London at a mere nominal charge, while the incoming cases from England continue to be transported free of cost, by the Cunard and Inman Lines.

A full list and account of the transportation lines to which the Institution is indebted for the privilege of free freight was given in the Smithsonian Report for 1886.

*Centers of distribution.*—No changes have taken place among the distributing agents abroad, all of whom deserve the warmest thanks for the prompt and efficient manner in which they have discharged their mostly voluntary duties.

For a complete list of agents for the distribution of Smithsonian exchanges, I beg to refer to the report for 1886.

*Shipments made to foreign countries.*—With the increase in the business a more rapid method of intercourse had to be devised, and now the shipments have become very frequent, with but very short intervals.

The following table exhibits the dates of transmissions during the present year to each of the foreign countries corresponding with the Institution:

*Shipments to foreign countries.*

Country.	Date.
Algeria .....	December 16, 1886.
Argentine Republic .....	July 29, November 8, 1886; January 24, June 27, 1887.
Austria-Hungary .....	July 23, August 25, September 14, October 15, December 11, December 27, 1886; January 29, February 10, February 25, March 11, April 19, May 3, May 12, May 19, June 1, June 18, June 30, 1887.
Belgium .....	July 28, September 28, December 14, 1886; January 18, February 16, May 23, June 20, June 29, 1887.
Bolivia .....	September 7, 1886.
Brazil .....	July 30, November 8, 1886; January 24, June 27, 1887.
British America .....	August 5, August 17, October 25, November 11, December 3, December 17, 1886; March 22, 1887.
British Colonies .....	August 5, November 6, 1886.
Cape Colony .....	December 16, 1886.
Chili .....	July 30, 1886; January 24, June 27, 1887.
China .....	February 21, 1887.
Colombia, United States of .....	July 31, 1886.
Costa Rica .....	August 1, 1886.
Cuba .....	March 19, 1887.
Denmark .....	July 28, September 27, 1886; February 18, June 25, 1887.
Ecuador .....	July 31, 1886; January 24, 1887.
Egypt .....	December 16, 1886.
France .....	July 26, August 25, September 11, September 14, October 21, November 24, December 3, December 14, 1886; January 18, January 28, February 10, February 25, March 25, March 31, May 2, May 9, May 12, May 19, June 14, June 18, June 30, 1887.

*Shipments to foreign countries—Continued.*

Country.	Date.
Germany .....	July 23, August 11, August 25, September 14, October 15, December 11, December 16, December 27, 1886; January 7, January 20, February 10, February 25, March 11, March 16, April 19, May 3, May 13, May 19, June 1, June 14, June 18, June 30, 1887.
Great Britain and Ireland.	July 21, August 11, September 5, October 18, December 9, December 18, December 29, 1886; January 27, February 11, March 12, April 5, April 21, May 3, May 13, May 19, May 20, June 2, June 14, June 18, June 28, 1887.
Greece .....	February 18, June 24, 1887.
Guatemala .....	April 1, 1887.
Hayti .....	March 19, 1887.
Holland .....	July 30, November 1, 1886; January 31, May 23, June 21, 1887.
Iceland .....	September 27, 1886; February 17, 1887.
India .....	July 13, August 3, November 11, 1886; February 21, 1887.
Italy .....	July 26, September 22, November 23, 1886; January 8, January 17, March 17, April 29, May 21, June 18, 1887.
Japan .....	August 3, November 11, 1886; February 21, March 14, 1887.
Mexico .....	July 27, August 5, October 29, November 28, 1886; January 21, June 25, 1887.
New South Wales .....	August 2, November 6, 1886; May 27, 1887.
New Zealand .....	August 2, November 6, 1886; May 28, 1887.
Norway .....	July 2, July 29, August 25, 1886; March 15, June 11, June 21, 1887.
Peru .....	July 31, 1886; January 24, 1887.
Portugal .....	August 5, September 29, 1886; February 19, June 21, 1887.
Queensland .....	August 2, November 6, 1886; May 27, 1887.
Russia .....	July 27, September 30, December 1, 1886; January 18, February 2, April 28, May 12, May 24, June 20, 1887.
Sandwich Islands .....	July 31, 1886.
South Australia .....	August 2, November 6, 1886.
Spain .....	August 3, September 28, 1886; February 19, May 25, June 24, 1887.
Sweden .....	July 6, July 27, September 25, 1886; March 26, April 25, May 25, June 24, 1887.
Switzerland .....	July 29, October 30, 1886; February 1, April 29, June 20, 1887.
Surinam .....	September 21, 1886; January 24, 1887.
Tasmania .....	November 6, 1886.
Turkey .....	July 28, 1886; June 14, 1887.
Uruguay .....	July 31, 1886.
Venezuela .....	July 31, 1886.
Victoria .....	August 2, November 6, 1886; May 27, 1887.
West Indies .....	March 19, 1887.

In addition to the above transmissions of Smithsonian miscellaneous exchanges, the following sendings of Government exchanges were made:

	Boxes.
Two transmissions of 39 boxes .....	78
One transmission .....	20
One transmission .....	27
One transmission .....	38

It has been suggested that the intervals between the receipt, by the Smithsonian Institution, of packages and their delivery to the consignee might perhaps be lessened by some improved method of transmission. If there is ground for complaint of tardiness in the delivery, such charge can certainly not be made against the exchange office, in which but very small delays occur between the receipt of exchange packages and their transmission.

In order to illustrate this assertion I now beg to submit the following tables of transmissions to France, Germany, Great Britain, and Italy. In each case twenty invoices have been selected at random, extending over a period of almost three years, and their history has been traced from the ledger accounts as follows:

## FRANCE.

Sender.	No. of society.	By exchange office.		Acknowledged.	
		Received.	Sent.	By agent.	By consignee.
Boston Society of Natural History.	2353	Dec. 5, 1884	Jan. 17, 1885	.....	Mar. 1, 1885
U. S. Geological Survey.	2461	Feb. 19, 1885	Apr. 1, 1885	May 29, 1885	May 22, 1885
Bureau of Ethnology.	2473	Apr. 14, 1885	Apr. 17, 1885	May 28, 1885	May 30, 1885
U. S. Geological Survey.	2511	May 11, 1885	May 15, 1885	June 23, 1885	June 30, 1885
Smithsonian Institution.	2516	July 3, 1885	July 10, 1885	Aug. 20, 1885	Aug. 24, 1885
Geological Survey of Pennsylvania.	2527	Sept. 15, 1885	Sept. 17, 1885	Oct. 21, 1885	Oct. 28, 1885
Boston Society of Natural History.	2561	Oct. 14, 1885	Nov. 7, 1885	Dec. 14, 1885	Mar. 20, 1886
California Academy.	2587	Apr. 2, 1886	Apr. 29, 1886	May 28, 1886	June 4, 1886
New York Academy of Science.	2596	May 28, 1886	June 18, 1886	Aug. 28, 1886	Aug. 21, 1886
U. S. Geological Survey.	2599	July 10, 1886	July 26, 1886	Aug. 30, 1886	Sept. 11, 1886
Smithsonian Report 1884.	2609	Aug. 24, 1886	Aug. 25, 1886	Sept. 28, 1886	Oct. 20, 1886
Acta Mathematica.	2617	Aug. 31, 1886	Sept. 11, 1886	Oct. 9, 1886	Oct. 1, 1886
Nautical Almanac.	2633	Sept. 20, 1886	Oct. 21, 1886	Nov. 24, 1886	Dec. 8, 1886
California Academy.	2731	Oct. 25, 1886	Nov. 24, 1886	Jan. 20, 1887	Jan. 26, 1887
American Philosophical Society.	2735	Jan. 13, 1887	Jan. 28, 1887	Mar. 4, 1887	Mar. 10, 1887
U. S. Geological Survey.	2783	Feb. 7, 1887	Feb. 10, 1887	Mar. 11, 1887	Mar. 16, 1887
New York Academy of Science.	2783	Mar. 22, 1887	Mar. 22, 1887	Apr. 26, 1887	May 1, 1887
Bureau of Ethnology.	2761	Apr. 29, 1887	May 2, 1887	June 8, 1887	June 11, 1887
American Academy, Boston.	2845	Apr. 19, 1887	May 9, 1887	June 9, 1887	June 17, 1887
Smithsonian Report 1885, Part I.	2855	June 17, 1887	June 18, 1887	Aug. 3, 1887	Aug. 11, 1887

## GERMANY.

Bureau of Ethnology.	3071	Dec. 23, 1884	Jan. 13, 1885	Mar. 3, 1885	June 30, 1885
Dr. W. J. Hoffman.	3091	Feb. 24, 1885	Mar. 18, 1885	Apr. 22, 1885	June 25, 1885
U. S. Geological Survey.	3147	June 26, 1885	June 30, 1885	Aug. 25, 1885	Oct. 22, 1885
Department of the Interior.	3165	July 13, 1885	July 17, 1885	do .....	Oct. 21, 1885
Boston Society of Natural History.	3213	Oct. 14, 1885	Nov. 6, 1885	Dec. 16, 1885	Feb. 5, 1886
U. S. Geological Survey.	3223	Feb. 9, 1886	Feb. 24, 1886	Apr. 6, 1886	May 18, 1886
American Philosophical Society.	3237	Mar. 25, 1886	Mar. 29, 1886	May 12, 1886	July 9, 1886
California Academy.	3295	Apr. 2, 1886	May 3, 1886	June 7, 1886	July 12, 1886
U. S. Geological Survey.	3299	July 10, 1886	July 23, 1886	Aug. 24, 1886	Oct. 14, 1886
Smithsonian Report 1884, I.	3307	Aug. 24, 1886	Aug. 25, 1886	Nov. 7, 1886	Nov. 15, 1886
Acta Mathematica.	3309	Aug. 31, 1886	Sept. 14, 1886	do .....	Nov. 10, 1886
Nautical Almanac.	3311	Sept. 21, 1886	Oct. 15, 1886	Nov. 20, 1886	Jan. 29, 1887
Smithsonian Report 1884, II.	3313	Dec. 23, 1886	Dec. 27, 1886	Feb. 18, 1887	Mar. 24, 1887
Comptroller of the Currency.	3345	Feb. 4, 1887	Feb. 25, 1887	Apr. 2, 1887	Apr. 20, 1887
Department of the Interior.	3383	Mar. 14, 1887	Apr. 19, 1887	May 21, 1887	July 7, 1887
U. S. Geological Survey.	3637	May 9, 1887	May 12, 1887	June 15, 1887	Do.
Smithsonian Institution, M. C. 28-30.	3737	May 19, 1887	May 19, 1887	June 18, 1887	Do.
Smithsonian Institution.	3775	June 14, 1887	June 30, 1887	Aug. 3, 1887	Sept. 9, 1887
Dr. W. J. Hoffman.	4589	May 13, 1887	June 1, 1887	July 5, 1887	July 15, 1887
Bureau of Ethnology.	4651	June 8, 1887	June 14, 1887	July 21, 1887	July 25, 1887



## GREAT BRITAIN.

Sender.	No. of society.	By exchange office.		Acknowledged.	
		Received.	Sent.	By agent.	By consignee.
Bureau of Ethnology .....	5421	Apr. 14, 1885	Apr. 17, 1885	May —, 1885	May 20, 1885
New York State Library .....	5485	June 2, 1885	June 22, 1885	July 25, 1885	July 31, 1885
American Academy, Boston .....	5195	July 23, 1885	Aug. 1, 1885	Sept. 12, 1885	Sept. 22, 1885
U. S. Geological Survey .....	5497	Aug. 4, 1885	Sept. 2, 1885	Oct. 5, 1885	Dec. 30, 1885
Smithsonian Report, 1883 .....	5505	Oct. 12, 1885	Oct. 12, 1885	Nov. 24, 1885	Nov. 27, 1885
U. S. Geological Survey .....	5529	Oct. 19, 1885	Oct. 27, 1885	Dec. 8, 1885	Dec. 14, 1885
Do .....	5531	Nov. 30, 1885	Jan. 8, 1886	Mar. 23, 1886	Mar. 10, 1886
Smithsonian Report, 1884, I .....	5537	May 5, 1886	May 7, 1886	July 15, 1886	July 5, 1886
U. S. Geological Survey .....	5541	May 10, 1886	May 9, 1886	do .....	July 12, 1886
National Academy of Sciences .....	5567	May 21, 1886	May 25, 1886	July 14, 1886	July 16, 1886
U. S. Geological Survey .....	5609	June 1, 1886	June 16, 1886	July 23, 1886	July 29, 1886
Acta Mathematica .....	5645	Aug. 31, 1886	Sept. 3, 1886	Oct. 19, 1886	Nov. 3, 1886
American Philosophical Society .....	5663	Sept. 3, 1886	Oct. 18, 1886	Dec. 21, 1886	Dec. 2, 1886
Smithsonian Report, 1884, II .....	5669	Dec. 23, 1886	Dec. 28, 1886	Mar. 26, 1887	Apr. 12, 1887
U. S. Geological Survey .....	5673	Jan. 6, 1887	Jan. 27, 1887	do .....	Mar. 26, 1887
Do .....	5683	Feb. 7, 1887	Feb. 11, 1887	Apr. 23, 1887	Apr. 18, 1887
Trenton (N. J.) Natural History Society .....	5689	Feb. 25, 1887	Mar. 12, 1887	do .....	May 24, 1887
New York Academy .....	5695	Mar. 22, 1887	Apr. 5, 1887	May 17, 1887	May 20, 1887
Bureau of Ethnology .....	5697	June 8, 1887	June 14, 1887	July 16, 1887	July 20, 1887
Smithsonian Report, 1885, I .....	5701	June 17, 1887	June 18, 1887	July 21, 1887	July 26, 1887

## ITALY.

Bureau of Ethnology .....	6671	Dec. 23, 1884	Jan. 26, 1885	June 25, 1885	Nov. 30, 1885
Do .....	6695	Apr. 14, 1885	Apr. 18, 1885	do .....	Sept. 20, 1885
Geological Survey of Minnesota .....	6325	Apr. 29, 1885	May 6, 1885	do .....	Oct. 27, 1885
Peabody Institute .....	6351	June 10, 1885	June 20, 1885	July 3, 1886	Apr. 7, 1886
Smithsonian Institution .....	6315	July 3, 1885	July 11, 1885	do .....	Apr. 8, 1886
National Academy of Sciences .....	6327	Nov. 23, 1885	Dec. 8, 1885	Mar. 31, 1886	Apr. 14, 1886
Bureau of Ethnology .....	6357	Jan. 8, 1886	Jan. 9, 1886	June 25, 1886	Oct. 31, 1886
Smithsonian Report, 1883 .....	6329	Feb. 15, 1886	Feb. 15, 1886	do .....	July 31, 1886
Smithsonian Report, 1884 .....	6335	May 5, 1886	May 5, 1886	do .....	Dec. 10, 1886
California Academy, etc. ....	6363	Apr. 2, 1886	May 24, 1886	do .....	Dec. 20, 1886
Academy of Natural Sciences, Philadelphia .....	6445	July 16, 1886	July 26, 1886	do .....	Mar. 25, 1887
Acta Mathematica .....	6447	Aug. 31, 1886	Sept. 24, 1886	Dec. 16, 1886	Mar. 1, 1887
Academy of Natural Sciences, Philadelphia .....	6365	Nov. 19, 1886	Nov. 23, 1886	Feb. 10, 1887	Mar. 18, 1887
John Hampden .....	6503	Jan. 3, 1887	Jan. 10, 1887	Mar. 7, 1887	Apr. 26, 1887
Smithsonian Report, 1884, II .....	6469	Jan. 17, 1887	Jan. 17, 1887	do .....	Mar. 27, 1887
Academy of Natural Sciences, Philadelphia .....	6525	Mar. 12, 1887	Mar. 17, 1887	do .....	Sept. 24, 1887
American Academy, Boston .....	6539	Apr. 19, 1887	Apr. 29, 1887	June 30, 1887	Do .....
Bureau of Ethnology .....	6503	Apr. 29, 1887	May 21, 1887	July 31, 1887	Aug. 25, 1887
Smithsonian Report, 1885, I .....	6649	June 17, 1887	June 18, 1887	Sept. 27, 1887	Oct. 3, 1887
Do .....	6691	do .....	do .....	do .....	Do .....

From the preceding tables the intervals between the receipt at and the shipment by the exchange office are shown to be as follows:

Country.	Longest.	Shortest.	Mean.
	Days.	Days.	Days.
France .....	42	0	15½
Germany .....	35	0	13½
Great Britain, etc. ....	45	0	12½
Italy .....	33	0	9½

It will also be noticed that in many instances the packages were shipped on the very day of their delivery to the exchange office.

*Shipments received from abroad.*

Country.	Date.
Argentine Republic.....	September 30, 1886.
Australia.....	December 5, 1886; January 3, March 4, 1887.
Belgium.....	October 14, December 17, December 27, 1886.
Brazil.....	February 25, 1887.
Central America.....	September 4, September 6, 1886.
Denmark.....	September 7, December 14, 1886; February 15, 1887.
France.....	September 1, September 6, November 12, November 23, December 1, 1886; January 24, February 8, February 10, April 21, 1887.
Germany (including Austria-Hungary).	July 28, August 19, September 16, September 18, September 30, October 30, November 20, December 4, 1886; January 6, January 8, February 10, February 25, March 15, March 31, April 8, May 5, May 26, June 6, 1887.
Great Britain and Ireland.	July 2, July 12, July 17, July 21, July 26, July 29, August 16, August 19, August 26, September 4, September 10, September 20, September 23, October 1, October 8, October 15, October 22, October 30, November 15, November 17, November 20, November 27, December 4, December 17, December 28, 1886; January 8, January 18, January 21, January 24, January 31, February 25, March 15, March 26, April 2, April 22, May 14, May 23, May 26, June 1, June 7, June 24, 1887.
Holland.....	August 7, November 29, 1886; April 11, 1887.
Italy.....	October 20, November 13, 1886; February 25, 1887.
Japan.....	December 18, 1886.
Mexico.....	December 28, 1886.
Norway.....	October 30, December 18, December 23, 1886; March 8, May 26, 1887.
Russia.....	November 13, 1886; May 14, 1887.
Sweden.....	October 30, 1886; May 14, 1887.
Switzerland.....	(Included in sendings from Germany.)

## II.—GOVERNMENT EXCHANGES.

The Smithsonian Institution, charged by the Government of the United States with the duties required for the execution of an exchange of official public documents with foreign Governments, as provided for by the laws of March 2, 1867, and July 25, 1868, has, during the past year, received from the Public Printer three hundred and seventy-one sets (of fifty copies each) of official publications. These were distributed in the usual manner to the contracting Governments of thirty-eight countries.

The Governments of Peru and Austria were added to the list, thus increasing the number of recipients to forty.

## EXCHANGE WITH AUSTRIA.

The first step toward establishing exchange relations with the Government of Austria was taken in 1876, by the transmission of the first two boxes of official publications, which were deposited in the Imperial Library at Vienna.

In 1884 the subject was again taken up on occasion of my mission to Europe, as described in the Smithsonian Reports for 1884 and 1885, but no definite arrangement could be decided on.

On the 14th of December the following letter was received by the Smithsonian Institution:

*The chargé d'affaires of Austria-Hungary to the Secretary of the Smithsonian Institution.*

WASHINGTON, D. C., December 14, 1886.

SIR: Having been instructed to transmit to the Smithsonian Institution a case which reached this legation yesterday, and which contains thirty-four volumes (and one register) of stenographic reports referring to the ninth session of both houses of the Imperial Parliament, I have the honor to inform you that said case shall be forwarded without delay to your address.

Please to acknowledge the receipt of said publications, and accept, sir, the renewed assurance of my high consideration.

Yours, very respectfully,

LIPPE-WEISSENFELS.

The first advance toward the accomplishment of the proposition for an exchange made by the United States having thus been made by the Imperial Government in Vienna, it was decided to make an immediate return in official publications of the United States Government, resulting in the following correspondence:

*The Secretary of the Smithsonian Institution to the consul-general of Austria-Hungary in New York.*

WASHINGTON, D. C., January 8, 1887.

SIR: The Smithsonian Institution, on behalf of the United States Government, is about presenting to the Imperial Government at Vienna a set of the United States official documents published since January 1, 1868, comprising twenty-five packing-boxes, with an approximate bulk of 160 cubic feet, and an aggregate weight of about 6,000 pounds.

In this transaction we desire the Imperial Government to be at the least possible expense, and we therefore propose to deliver the cases, freight prepaid, at an Austrian sea-port easy of access to Vienna, such as Trieste or Fiume, provided we could arrange for the shipment of the lot by some sailing vessel bound direct for one of those ports.

We are not cognizant of any regular sailing communication between the United States and Austria, and therefore beg to request your kind co-operation in the matter, by informing us of the existence of a regular line plying between New York and one of the above-named Austrian ports, or of the possibility of arranging with some Austrian vessel for the shipment, at reasonable rates, of the lot of books mentioned, which could be delivered in New York within forty-eight hours of any information received.

Very respectfully,

SPENCER F. BAIRD,  
*Secretary Smithsonian Institution.*



In reply to this letter the following communication was received :

*The Imperial and Royal Austro-Hungarian consulate-general, New York, to the Secretary of the Smithsonian Institution.*

NEW YORK, *January 17, 1887.*

SIR: In receipt of your esteemed favor of the 8th instant, I beg to say that I shall be most happy to co-operate with you in the matter of the shipment of a set of United States official documents to the Imperial Government at Vienna,

There is, unfortunately, no regular sailing communication between the United States and Austria, nor is there at this moment any sailing-vessel or steamer in port bound direct to Trieste or Fiume.

It may be that an opportunity will before long offer itself to ship the books by an Austrian sailing vessel to a home port, and in that case I shall not fail to communicate with you at once.

I have also given instructions to be promptly advised of the loading of any sailing vessel or steamer for Austrian ports, so as to make arrangements for this shipment.

I shall have the pleasure of reporting progress as soon as possible; and remain,

Very respectfully, etc.,

HUGO FRITSCH,  
*Consul.*

*The Imperial and Royal Austro-Hungarian consulate-general, New York, to the Secretary of the Smithsonian Institution.*

NEW YORK, *May 2, 1887.*

SIR: Referring to my last of January 17, a. c., I am to-day enabled to comply with your favor of January 8.

There is no Austrian vessel as yet for Trieste, but the Italian bark *Peppino Mignano* is now loading for that port and will sail in about two weeks.

The agents are Messrs. Funch, Edye & Co., 27 South William street, New York, whose card I inclose; they name \$5 and 5 per cent. per 40 cubic feet as lowest rate.

Very respectfully, etc.,

HUGO FRITSCH,  
*Consul.*

[Inclosure.]

Card of Funch, Edye & Co., ship brokers, 27 South William street, New York, stating "the Italian bark *Peppino Mignano* will sail for Trieste in about two weeks, from foot of Richard street, Erie Basin, Brooklyn. Freight \$5 and 5 per cent. per 40 cubic feet."

*The Smithsonian Institution to Dr. von Tavera, envoy, etc., of His Majesty the Emperor of Austria.*

WASHINGTON, D. C., *May 9, 1887.*

SIR: I have the honor inclosed to submit a copy of a communication addressed by the Smithsonian Institution on the 12th of October, 1885, to Count Lippe Weissenfels, the Imperial Austrian chargé d'affaires (this communication will be found on page 109 of the Smithsonian Annual Report for 1886, Part I), explanatory of the steps taken for the final

settlement of the question of an exchange of the official publications between the Government of His Majesty and that of the United States, proposed by the Smithsonian Institution, as the authorized agent of the Government in 1884.

Since then, on the 14th December, 1886, the first advance was made by the Austrian Government by the transmission, through His Majesty's legation, of a case containing the "stenographic reports referring to the ninth session of both houses of the Imperial Parliament," and being desirous of making an immediate return, we placed ourselves in communication with the Austrian consul-general in New York, relative to the best mode of forwarding our exchanges to the Austrian port most convenient to Vienna.

In compliance with our request, Consul-General Fritsch of New York now informs us that the Italian bark *Peppino Mignano* is about to sail for Trieste. Therefore, unless your excellency is prepared to provide for a channel of transmission, we propose to utilize the opportunity thus offered, and to send by this bark, freight prepaid, to Trieste the twenty-seven boxes of official documents (with a bulk of about 160 cubic feet and a total weight of about 7,000 pounds) required, additional to the two boxes already deposited in the Imperial Public Library in Vienna, to complete the series comprised in the exchange proposition, and now beg you to kindly arrange or have the Imperial Government arrange for their delivery to some responsible party in Trieste.

The annual addition to this collection will be about three boxes, and we desire instructions to deliver the same hereafter to the consul-general in New York for transmission to Vienna.

As provided for in the stipulations of exchanges proposed through Mr. Boehmer in 1884, we trust that the minister of foreign affairs in Vienna may be pleased to arrange for the collecting from the various departments and bureaus of the Government and from the scientific establishments and institutions under their care, of one copy each of all the publications made by them or under their direction, and to have the same forwarded to the agent of the Smithsonian Institution, Dr. Felix Flügel, 39 Sidonien Strasse, Leipzig, who has received instructions relative to their transmission to the United States.

With the assurance of my high consideration, etc.

SPENCER F. BAIRD,  
*Secretary.*

[Telegram.]

*Smithsonian Institution to Funch, Edye & Co., New York.*

WASHINGTON, D. C., May 10, 1887.

Will shipment for Trieste be in time for barque *Peppino Mignano*, and shall cases be addressed to your care or to vessel? Wire answer.

SMITHSONIAN INSTITUTION.

[Telegram.]

*Funch, Edye & Co., New York, to Smithsonian Institution.*

NEW YORK, May 10, 1887.

Vessel for Trieste will receive up to Saturday, this week. Must have clearance Saturday morning.

FUNCH, EDEY & CO.

*The Imperial and Royal Austro-Hungarian legation to the Secretary of the Smithsonian Institution.*

WASHINGTON, D. C., May 11, 1887.

SIR: I have had the honor to receive your letter dated May 9, by which you inform me of the transmission to the Imperial and Royal Government of twenty-seven boxes of official documents by way of the Austro-Hungarian consulate at New York. The said consular office will be accordingly instructed to take the proper steps for having the said cases shipped on the Italian bark *Peppino Mignano*.

I shall at the same time communicate to the Imperial and Royal Government your remarks with regard to the mutual exchange of official documents, and trust that this exchange will proceed in a regular and satisfactory way according to the mutually established stipulations.

Receive, sir, the assurance of my high consideration.

TAVERA,  
*Austro-Hungarian Minister.*

*The Smithsonian Institution to Hon. Hugo Fritsch, Imperial Austrian consul-general, New York.*

WASHINGTON, D. C., May 11, 1887.

SIR: Upon the receipt of your esteemed favor of the 2d instant, we placed ourselves in communication with the Imperial Austrian legation in this city, relative to some minor details regarding the final disposition of the cases of international exchanges for the Austrian Government, and now have the pleasure to inform you that we have sent to the care of Messrs. Funch, Edye & Co., 27 South William street, as suggested by you, twenty-seven cases of the official documents of the United States Government for transmission, freight prepaid, to Trieste, per Italian bark *Peppino Mignano*.

The minister announces to-day that he has written to you relative to these cases, and we beg you to make the necessary arrangement for their delivery to some responsible party in Trieste.

Thanking you for the interest you have taken in the subject, I am, etc.,  
SPENCER F. BAIRD,  
*Secretary.*

*The Smithsonian Institution to Messrs. Funch, Edye & Co., New York.*

WASHINGTON, D. C., May 11, 1887.

GENTLEMEN: Confirming the receipt of your telegram of yesterday, I now have the pleasure of announcing the shipment per Pennsylvania Railroad, to your care, of twenty-seven cases of exchanges for the Government of Austria. These we request you to forward to Trieste, subject to a possible arrangement for their delivery there by the Austrian consul in New York, per Italian bark *Peppino Mignano*, having the freight on the same prepaid to Trieste at the rate specified by you, \$5 and 5 per cent. per 40 cubic feet, and collecting the amount from us.

We also request you to announce to us the arrival and shipment of the cases, and to have two copies of the bill of lading mailed to us at your earliest convenience.

Very respectfully, etc.,

SPENCER F. BAIRD,  
*Secretary.*



*The Smithsonian Institution to Dr. von Tavera, Imperial and Royal Austrian envoy extraordinary.*

WASHINGTON, D. C., May 26, 1887.

SIR: Referring to previous correspondence on the subject, I have the honor to submit a copy of the bill of lading, per Italian bark *Pepino Mignano*, for the twenty-seven cases of official publications addressed by the Smithsonian Institution, on behalf of the Government of the United States, to the Imperial Government at Vienna.

The cases are numbered 1168-1194, and the freight on the same has been prepaid by us to Trieste, as per agreement.

I have the honor, etc.,

S. P. LANGLEY,  
*Acting Secretary.*

*The Imperial and Royal Austrian envoy extraordinary to the acting Secretary Smithsonian Institution.*

WASHINGTON, D. C., May 28, 1887.

SIR: I have the honor to acknowledge with thanks the receipt of your letter dated 26th instant, by which you transmitted to me the bill of lading for the twenty-seven cases of official publications addressed by the Smithsonian Institution to the Imperial and Royal Government.

Very respectfully, yours,

TAVERA,  
*Minister.*

#### EXCHANGES WITH PERU.

On the 16th of May, 1867, the Smithsonian Institution, as the agent of the United States Government for the exchange of official public documents with foreign nations as provided for by act of March 2, 1867, invited, among others, the Government of Peru to participate in the proposed exchange. The proposition was favorably received, and the acceptance, on the part of the Peruvian Government, expressed in a letter emanating from the foreign office in Lima, Peru, on the 30th December, 1867, and transmitted to the Smithsonian Institution through the United States Department of State. (See Smithsonian Annual Report for 1881, p. 760, 761; also History of Smithsonian Exchanges, Washington, 1882, pp. 58-59.)

By some inexplicable oversight this subject was completely lost sight of until in the beginning of the present fiscal year, when it was again brought to notice by Mr. Elmore, then the representative of the Peruvian Government at Washington, and chief clerk of the Peruvian foreign office in 1867, at the time of the acceptance of the proposition on the part of his Government.

In consequence relations were at once established, of which the following correspondence is a portion, and which terminated in the trans-

mission, by the Smithsonian Institution, of a set of twenty cases, addressed to the Government of Peru at Lima :

*Prof. Spencer F. Baird to the Secretary of State.*

WASHINGTON, D. C., July 2, 1886.

SIR: During the administration of my predecessor in office, the lamented Professor Henry, a letter dated February 8, 1868, was received from the then Secretary of State, Hon. William H. Seward, transmitting a note from the foreign office at Lima with reference to a proposition from this Institution for an exchange of official documents with the Republic of Peru. Printed copies of this correspondence I inclose.

In some inexplicable way the subject has been entirely lost sight of and has only just been brought to the light; and I beg to state that the Institution is now anxious to resume negotiations with the Peruvian Government relative to the proposed exchange.

The Smithsonian Institution as the agent for international exchanges on the part of the United States Government is prepared to furnish the Government of Peru with a collection of several thousand volumes of documents published by the United States since 1868. These can be delivered to the Peruvian consul at New York free of charge. The returns of publications on the part of Peru, which should be full and in as complete series as possible, should be delivered free of charge to the United States consul at Callao. The returns will be placed in the Library of Congress in accordance with existing law. The Peruvian Government, if desirous of renewing its acceptance of the proposition of the Institution, should, of course, furnish us with the name of the department designated to receive the books transmitted on behalf of the United States.

We should also be pleased to have the Peruvian department to which the business of the exchange is assigned take charge of and distribute the miscellaneous scientific exchanges presented by societies and individuals, through the Smithsonian Institution, to correspondents in that country, the Institution guaranteeing a like service for any parcels of similar character for the United States and Europe.

Very respectfully, etc.,

SPENCER F. BAIRD.

*Secretary.*

*The Secretary of State to Prof. Spencer F. Baird.*

WASHINGTON, August 2, 1886.

SIR: I transmit, with a reference to a recent letter of your Institution on the same subject, a copy of a communication from Mr. Elmore, the late minister of Peru to the United States, now in Washington, and beg to suggest that the cases of books which your Institution has for consignment to the Peruvian Government may be forwarded as desired, if agreeable to your methods.

I am, etc.,

T. F. BAYARD.

[Inclosure.]

*Mr. Elmore to the Secretary of State.*

WASHINGTON, July 31, 1886.

MY DEAR SIR: I take the liberty to call your attention to a matter of great interest and of much importance for Peru, and which, if the suggestion I am about to make is carried out, will be a source of real joy among all Peruvians who desire to

study and know better the United States and who wish to develop their own country by the arts of peace. I refer to the execution of the agreement in 1867 between Peru and the United States to exchange their respective Government publications.

This system of international exchanges, authorized by an act of Congress, March 2, 1867, proposed to foreign nations, through the State Department, in a circular by the Smithsonian Institution, May 16, 1867, was "accepted in all of its terms" by a decree of the President of Peru on 27th December, 1867. (See pages 58 and 59 of "A History of the Smithsonian Exchanges," by George H. Boehmer, from the Smithsonian Report for 1881.)

Through causes too long to state in this letter the exchange with Peru was imperfectly carried out, or not at all. Of course Peru, under any circumstances, would be benefited by the exchange more than the United States; but it is precisely on this account that I now beg to be allowed to address you on the subject, because my object is to request you to do Peru a great service, now needed more than at any time before.

It is known that one of the first acts of the Chilians when they occupied Lima in 1881 was to sack and destroy or carry away completely the whole of the old and valuable library of Lima. The Peruvian Government in 1883 began to take steps to form a new library, which has been created, having at present about 30,000 volumes, mostly the gift of foreign governments and institutions and of literary men and other private individuals.

During Secretary Frelinghuysen's time I made some efforts to obtain a few works of interest from this country, which in 1884 I presented to the new national library of Lima. But most of the United States publications destined for Peru since 1868 are kept in deposit, packed up in boxes, in the Smithsonian Institution, awaiting the order of your Government to be sent to the Peruvian Government, who will in return send to the Smithsonian Institution, for the Library of Congress, a full set of the official and other publications of Peru.

As now, after many years of disorder, Peru has a regularly elected constitutional government, the opportunity to send the Smithsonian exchanges to Peru is most admirable, and the benefit you will confer on Peru will be very great and will be fully appreciated.

On the 9th of August, probably, a gentleman of New York, intimately connected with the commerce of Peru, and whose firm (that of Messrs. W. R. Grace & Co., Hanover Square, New York) holds important contracts with the Peruvian Government, leaves for Lima. During a very long time no opportunity so good as this will present itself to have the valuable Smithsonian collection sent to Peru. The books are ready, packed up in about eighteen cases (measuring about 50 cubic feet), and containing over 1,000 volumes.

The United States Government would have no expense in this matter. As usual, the Smithsonian Institution would forward the cases to New York, and Messrs. W. R. Grace & Co. would attend to the shipping for account of the Peruvian Government.

I earnestly beg you, Mr. Secretary, to let the books be sent at once to the Government of Peru, as, going as they would, under the personal care of Mr. W. R. Grace, they would arrive with the greatest safety. The Smithsonian Institution only awaits your directions to forward the cases to New York.

Believe me, etc.,

J. F. ELMORE.

*Prof. Spencer F. Baird to the Secretary of State.*

WASHINGTON, D. C., August 9, 1886.

SIR: Referring to your communication of August 2, in reply to a letter from this Institution on the same subject, I beg to say that your suggestion with reference to the publications of the United States for the Government of Peru has been favorably considered, and twenty boxes containing the same are forwarded to the care of Messrs. Grace & Co., in New York, for shipment to Peru.

I have the honor to be, etc.,

S. F. BAIRD,  
*Secretary.*

*The Secretary of State to Prof. S. F. Baird.*

WASHINGTON, November 3, 1886.

SIR: I have to say, in further reply to your letter of the 2d July last, that the Peruvian Government is anxious to continue the arrangements



for the exchange of public documents with the Government of the United States. I inclose a copy of a note from Mr. Rivas, the minister of foreign affairs at Lima, on the subject.

I am, etc.,

T. F. BAYARD.

[Inclosure.]

*Minister of foreign relations, Lima, to Hon. T. F. Bayard, Secretary of State.*

LIMA, September 13, 1886.

MR. MINISTER: I have had the honor of receiving the very polite dispatch of your excellency relative to the exchange of publications between Peru and the United States.

In reply, I have the pleasure of manifesting to your excellency that my Government has a lively desire to maintain the arrangement celebrated in 1867 with the Smithsonian Institution, having to that end authorized the director of the national library to make remittances of Peruvian works with such exactness as is possible.

My Government appreciates and esteems at its value this literary exchange between two sister peoples of similar political institutions, in which is illustrated a spirit redounding in benefits to society.

The library of Lima, which was destroyed by the invading army, has been re-established through the generous co-operation of friendly Governments and foreign scientific societies, among which the Smithsonian has distinguished its efforts superior to all.

My Government desires, in making this expression of its gratitude, that through the worthy medium of your excellency it be placed in the knowledge of the Secretary of that Institution, manifesting at the same time that it will not omit efforts to perpetually comply with the arrangement to which I have referred.

Reiterating with this motive to your excellency assurances of my most high and distinguished consideration.

M. M. RIVAS.

#### DEFECTS OF THE EXCHANGE SYSTEM.

In carrying on the operations of an international exchange of official publications, the Smithsonian Institution, as the agent of the United States Government, experiences two difficulties, which it has for many years endeavored to overcome, without, however, fully accomplishing the desired end.

These obstacles are—

- (1) The failure to procure the fifty copies of each and every public document for exchange purposes; and
- (2) The inability to secure, by means of correspondence alone, the entire fruits of the wise provision of Congress in the way of adequate returns from foreign Governments for the books sent by us.

The first point has been the subject of repeated appeal to Congress, and I now beg to present the correspondence illustrating our last effort in that direction:

*The Smithsonian Institution to the Hon. A. R. Spofford, Librarian of Congress.*

WASHINGTON, D. C., February 21, 1887.

SIR: On the 7th of March, 1884, and on October 7, 1885, the Secretary of the Smithsonian Institution had the honor to address the Hon. John Sherman, chairman of the Joint Library Committee of Congress, as follows:

“After overcoming many obstacles, the Smithsonian system of exchanges has now been placed upon a most satisfactory basis, the only difficulty of any magnitude yet remaining being inability on the part



of the Smithsonian Institution, as the Government intermediary, to secure the entire fruit of the wise provision of Congress in the way of fifty copies of each and every public document for exchange purposes, and to this extent the system is yet imperfect. In the absence of strict compliance with the stipulation that all works published by the United States—its Congress, Executive Departments, Bureaus, etc.—shall be furnished for the purpose, the Institution can hardly exact from foreign Governments that have entered into an international exchange alliance copies of everything they, respectively, issue.

“I would therefore ask you respectfully to consider the several enactments upon the subject of international exchange, and that such supplementary legislation be provided as will enable us to surmount the difficulty referred to.”

In the absence of any action on the subject as requested, Professor Baird, on the 18th of January, 1886, addressed himself to the Hon. William J. Sewell, chairman of the Joint Library Committee of Congress, as follows:

“It again becomes the duty of the Smithsonian Institution, as the agent for the Government exchanges under appointment of Congressional act of March 2, 1867, to suggest a review by the Library Committee of the several enactments upon the subject of international exchanges, to the end that such additional legislation be provided as will render the Institution able to enforce strict compliance (on the part of the Public Printer and the various Departments and Bureaus of the Government) with the order of Congress *that all works published by the United States of America, whether by its Congress, its Executive Departments, or its Bureaus, and whether printed at the Public Printing Office or elsewhere, be furnished the Smithsonian Institution in fifty copies of each of the three distinct series, as specified in the acts of March 2, 1867, and July 25, 1868, and without which the Government of the United States, through the Library of Congress, will fail to reap the full benefit of that complete exchange which was intended and desired when the American Congress first exhibited its enlightened liberality in the wise provision for an exchange of United States official publications for those of foreign nations.*”

The letter was accompanied by a memorandum specifying the various enactments on international exchange, and illustrating the defects of existing laws on the subject.

No attention, however, was given by the Joint Library Committee to the request for a consideration of the requirements as pointed out by the Institution, and the present session of Congress drawing to a close without any action having been had in relation to it, I beg to invite your co-operation—as the party most interested in the results of the service—by requesting you to bring the matter before the proper committee, for whose information and guidance, in connection with any new legislation which it may deem proper to suggest for the consideration of Congress, I inclose herewith a brief sketch of existing laws on the subject.

In order to obtain for the international exchange the advantages desired by Congress, the laws governing it should be amended so as to make it obligatory on the part of the Public Printer, the Executive Departments and Bureaus of the Government to furnish the fifty copies of each and every publication made by them, of whatever class or description, called for by the original acts of March 2, 1867, and July 25, 1868.

I am, sir, etc

S. P. LANGLEY,  
Assistant Secretary.

[Inclosure.]

On the 2d day of March, 1867, Congress passed the following resolution (Stat. at Large, vol. 14, p. 573):

*“Resolved by the Senate and House of Representatives of the United States in Congress assembled, That fifty copies of all documents hereafter printed by order of either House of Congress, and fifty copies additional of all documents printed in excess of the usual number, together with fifty copies of each publication issued by any Department or Bureau of the Government, be placed at the disposal of the Joint Committee on the Library, who shall exchange the same, through the agency of the Smithsonian Institution, for such works published in foreign countries, and especially by foreign Governments, as may be deemed by said committee an equivalent; said works to be deposited in the Library of Congress.”*

This resolution provides, as plainly and distinctly expressed, for three times fifty copies of certain official publications, or, rather, for fifty copies each of three different and distinct issues into which the publications of the United States Government may be classed:

*I. The Congressional issue*, consisting of series of journals, reports of committees, miscellaneous documents, and executive documents.

*II. The annual reports of the Executive Departments and Bureaus of the Government.*

*III. The memoirs, monographs, and special reports* published by the Executive Departments and Bureaus of the Government.

*Of the first issue* (the Congressional), the usual number printed is, as prescribed in section 3792 Revised Statutes, “fifteen hundred and fifty copies of any document ordered by Congress,” etc., increased to nineteen hundred, which includes the installments for distribution by the Congressional Library and for exchange in foreign countries.

Section 3799 provides that “of the documents printed by order of either House of Congress there shall be printed and bound fifty additional copies for the purpose of exchange in foreign countries.”

*The second series* is formed by the “extra copies” ordered to be printed by Congress *in addition to the usual number*, and represent the annual report of the Executive Departments and Bureaus of the Government, Reports on Foreign Affairs, Commerce and Navigation, Commercial Relations, etc., and as such form each an independent series of Government publications.

Relative to this issue, section 3796 Revised Statutes provides: “The Congressional Printer shall, when so directed by the Joint Committee on the Library, print in addition to the usual number either fifty or one hundred copies, as he may be directed, of all documents printed by either House of Congress or by any Department or Bureau of the Government.”

Resolution No. 72, second session Fortieth Congress (approved July 25, 1868), a resolution to carry into effect the resolution approved March 2, 1867, providing for the exchange of certain public documents, specifies: “That the Congressional Printer, whenever he shall be so directed by the Joint Committee on the Library, be, and he hereby is, directed to print fifty copies in addition to the regular number of all documents hereafter printed by order of either House of Congress, or by order of any Department or Bureau of the Government, and whenever he shall be so directed by the Joint Committee on the Library, one hundred copies additional of all documents ordered to be printed in excess of the usual number; said fifty or one hundred copies to be delivered to the

Librarian of Congress, to be exchanged under the direction of the Joint Committee on the Library, as provided for by joint resolution approved March 2, 1867."

*The third series*, the memoirs, monographs, or special reports published by the Executive Departments and Bureaus of the Government, is provided for by section 2 of the above joint resolution No. 72, second session Fortieth Congress, approved July 25, 1868—a resolution to carry into effect the resolution approved March 2, 1867, providing for the exchange of certain public documents, as follows: "*And be it further resolved*, That fifty copies of each publication, printed under the direction of any Department or Bureau of the Government, whether at the Congressional Printing Office or elsewhere, shall be placed at the disposal of the Joint Committee on the Library to carry out the provision of said resolution."

Subsequent to this resolution becoming a law the Hon. E. D. Morgan, chairman of the Joint Committee on the Library, addressed the following letter to the Public Printer, J. D. Defrees, esq.:

"WASHINGTON, D. C., *October 24, 1868.*

"I have the honor to call your attention to the provisions of the resolution of Congress inclosed, approved July 25, 1868, and to request that the fifty copies of all documents now being printed and hereafter to be printed at the Congressional Printing Office, whether by order of either House of Congress or any of the Departments or Bureaus of the Government, be furnished by you, as fast as each edition is printed and bound, to the Librarian of Congress, for the purpose specified in the resolution.

"I would also request that of the Patent Office report and Agricultural report now being printed one hundred copies additional (or one hundred and fifty copies in all) be delivered to the Librarian for the purpose indicated."

On September 22, 1869, the Librarian of Congress addressed the Public Printer, on the subject of books required by law for the international exchange of official documents as follows:

"Your attention is respectfully called to the provisions of the resolution of Congress approved July 25, 1868, requiring the Congressional Printer to furnish to the Librarian of Congress fifty copies of all documents printed under whatever authority for the purpose of exchanging the same for the publications of foreign Governments, which are to be deposited in this Library.

"The official direction from the chairman of the Joint Committee on the Library, to print and deliver these documents required by the resolution, was communicated to your predecessor, Mr. J. D. Defrees, on the 24th of October, 1868. (See letter of Hon. E. D. Morgan, chairman, of that date.) The only reply received was a verbal one from Mr. Defrees, to the undersigned, that the documents should be regularly forwarded, and that the one hundred and fifty copies (fifty regular and one hundred extra) of the Agricultural and Patent Office reports for 1867, then on the press, would also be supplied. Not having received any documents whatever under this act of Congress, and the purpose of the same being to enrich the Library with as large a number and variety of the documents of foreign Governments as can be procured in exchange for our own, you are requested to have placed at my disposal fifty copies of each book, pamphlet, circular, army order, or other publication, by whatever authority printed, and one hundred copies additional of all



documents printed in excess of the usual number, to enable me to carry out the resolution of Congress referred to."

And again in reply to an inquiry on the part of the Public Printer, the following communication was addressed to that official on September 30, 1869:

"In reference to the documents not of Congress, but of the Departments and Bureaus of the Government, of which fifty copies are required by resolution of Congress to be furnished to the Library for international exchange, I have to say that all such documents as are printed at the public expense (with the single exception of printed instructions or confidential official communications) are important and will properly be furnished. The foreign Governments with which the exchanges are made furnish us with great fullness the specially printed documents they print in each department of their public service, and it is desired to make a return in kind."

Owing to the failure of the Public Printer to comply with those portions of the law relating to the second and third series of the United States official publications, the annual reports of the Executive Departments and Bureaus of the Government, and the memoirs, monographs, and special reports by the Executive Departments and Bureaus of the Government, although occasionally some few of the works of these classes have been received, a circular letter was addressed by the Smithsonian Institution on the 15th of February, 1884, to all the Departments and Bureaus of the Government, soliciting co-operation, in compliance with the existing laws, to enable the Institution, as agent of the Government, to carry out the provisions of the Congressional resolutions.

Among the replies received, that of the Hon. Secretary of State says:

I have ventured to suggest to the Joint Committee on the Library the desirability of a permanent provision for the printing of these required copies.

Appended to the letter of the Secretary of the Smithsonian Institution of March 7, 1884, is a list of the more important documents not furnished to the Smithsonian Institution although they are embraced in the series intended by Congress for exchange purposes.

Among the documents not furnished by the Public Printer may again be mentioned the following (assuming series I, the Congressional issue, to be complete as delivered, although even therein are many deficiencies):

Series II. *The annual reports of the Executive Departments and Bureaus of the Government, together with the papers accompanying such reports.* (Section 3796, Rev. Stat., and Resol. 72, second sess. Fortieth Congr.)

Series III. *The memoirs, monographs, or special reports published by the Executive Departments or Bureaus of the Government, whether printed at the Government Printing Office, or elsewhere.* (Section 2, Resolution No. 72, second session Fortieth Congr.)

This last series comprises, among many others, the following valuable publications :

*Patent Office :*

Official Gazette—thirty-two volumes published.

Specifications and Drawings—two hundred volumes published since 1872.

Growth of Industrial Art—two volumes, folio. Of this only fifty copies were printed.

*U. S. Geological Survey :*

Bulletins—thirty numbers issued.

Monographs—eleven volumes issued, of which only Vol. II and Atlas were received.

A letter was addressed to the Director of the Survey, February 18, 1884, claiming fifty copies of all the publications of that office for exchange purposes under the law. In reply the Director states, February 26, 1884 :

Under the law of March 2, 1867, fifty copies of everything published by us should be sent to the Library of Congress, and thence to the Smithsonian Institution by the Public Printer, and such copies are reserved for that purpose, and do not come into our possession.

Under the statutes relating to the publication of the monographs of the Geological Survey it would be impossible to spare any copies from the three thousand received by this office from the fact that it is necessary for the Survey to render an account of its publications, either as sold, exchanged, or on hand.

*Ethnological Bureau :*

Contributions to North American Ethnology. Only vols. 1, 3, and 4 received.

Pilling : Proof-sheets of North American Languages. Of this only one hundred copies were printed.

*Tenth Census of the United States :*

Monographs. Not one has been received.

*Fish Commission :*

Bulletins, vols. 1-5.

*State Department :*

Consular Reports. Only the first twenty-two have been received.

*Coast and Geodetic Survey :*

Publications.

*American and Foreign Claims Commissions :*

France, Hayti, Spain, Alabama, etc., neither of which has been received.

And, in fact, all the publications of the Departments and Bureaus of the Government, as *independent series*, although they may have been furnished as Congressional (miscellaneous) documents, which, however, constitute a distinct series (I) in themselves.

The second point, the inability to secure the entire fruits of the provisions of Congress, in the way of adequate returns, was fully discussed by Professor Baird on page 20 of the Annual Report of the Smithsonian Institution for 1885, by Mr. Spofford, the Librarian of Congress, on pages 25 and 26 of the Smithsonian Report for the fiscal year 1885-'86, and by myself, in the appendix to each of these reports.

The remedy suggested in the case was based on the experience of my mission to Europe, and the predictions ventured that, without the establishment of a permanent agency on the ground to attend personally to the whole business, only temporary results would be obtained, are fully borne out by the experience of the past year.

While the returns secured by my personal efforts comprise 44 cases and 160 packages of books, numbering about 7,000 volumes, collected from fourteen European Governments, the returns of the present year received from European Governments through the medium of the exchange service represent only 3 boxes and about 250 volumes of books.



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GENERAL APPENDIX

TO THE

SMITHSONIAN REPORT FOR 1886-'87.

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## ADVERTISEMENT.

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The object of the GENERAL APPENDIX is to furnish summaries of scientific discovery in particular directions; occasional reports of the investigations made by collaborators of the Institution; memoirs of a general character or on special topics, whether original and prepared expressly for the purpose, or selected from foreign journals and proceedings; and briefly to present (as fully as space will permit) such papers not published in the "Smithsonian Contributions" or in the "Miscellaneous Collections" as may be supposed to be of interest or value to the numerous correspondents of the Institution.

# RECORD OF SCIENTIFIC PROGRESS.

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## INTRODUCTION.

While it has been a prominent object of the Board of Regents of the Smithsonian Institution, from a very early date in its history, to enrich the annual report required of them by law, with scientific memoirs illustrating the more remarkable and important developments in physical and biological discovery, as well as showing the general character of the operations of the Institution, this purpose had not been carried out on any very systematic plan. Believing however that an annual report or summary of the recent advances made in the leading departments of scientific inquiry would supply a want very generally felt, and would be favorably received by all those interested in the diffusion of knowledge, the Secretary had prepared for the report of 1880, by competent collaborators, a series of abstracts showing concisely the prominent features of recent scientific progress in astronomy, geology, physics, chemistry, mineralogy, botany, zoölogy, and anthropology.

The same general programme has been followed in the subsequent reports, until the last, that for 1886, when the incompleteness of the record obtained, the discouragement from the increasing delay encountered in the printing of the annual summaries, and other considerations, induced the temporary suspension of the project. The postponed contributions are herewith presented, with the regret that the expected articles on meteorology and on botany are unavoidably omitted by reason of the pressing occupations of Professors Abbe and Farlow, their accustomed expositors, having prevented the undertaking.

With every effort to secure prompt attention to the more important details of a general survey of the annual progress of scientific discovery, experience has shown that various unexpected delays render it impracticable to obtain all the desired reports in each department within the time prescribed; and the plan attempted of bringing up the deficiencies in subsequent reports has not proved entirely satisfactory.

An appropriate introduction to the annual record is found in Professor Huxley's excellent sketch of the Advance of Science in the Last Half Century, which is herewith reprinted by permission of the publisher and of the author. This paper is one of a series setting forth the legislative, political, and civil condition of England during the reign of Queen Victoria, the progress of the nation in industrial arts, education, sci-



ence, literature, arts, etc., as a memorial of the jubilee year of the Queen, which was celebrated June 20, 1887. This semi-centennial corresponds—not, indeed, with the period of the life of the Smithsonian Institution, but with the interval from the time of securing the Smithsonian fund to the United States. The formal organization of the Institution was not effected till nearly ten years later.

Notwithstanding the acknowledged educational value of these general summaries of the annual advances of scientific investigation, and the popular interest that has been manifested in this feature of the Smithsonian Reports, various difficulties in the practical execution of the scheme have arisen to render the continuance of the experiment of doubtful expediency. In view of the numerous important fields of scientific inquiry which have been necessarily omitted from the programme, for lack of space for their presentation, (such as mathematics, physiology, microscopy, etc.,) as well as of the entire domain of the more popular topics embraced in the practical applications of science, (such as horticultural and agricultural economy, engineering, mechanics, and technology in general,)—the policy of attempting so inadequate a survey of intellectual and industrial advancement, with its ever-increasing range and complexity of development, may well be questioned. To all this must be added the consideration that the numerous demands upon the limited Smithsonian fund render it unable to bear the burden that a just award to the collaborators engaged would require from it.

Accordingly after perhaps another year of the more systematic treatment of scientific progress as latterly undertaken, it is probable that it may be thought advisable to revert to the earlier plan of publishing each year a number of papers possessing a popular interest—selected from foreign and domestic scientific journals or the Proceedings and Transactions of learned societies, together with such original articles as may appear to deserve general attention.

## ADVANCE OF SCIENCE IN THE LAST HALF CENTURY.\*

By T. H. HUXLEY, F. R. S.

The most obvious and the most distinctive feature of the history of civilization during the last fifty years is the wonderful increase of industrial production by the application of machinery; the improvement of old technical processes and the invention of new ones, accompanied by an even more remarkable development of old and new means of locomotion and inter-communication. By this rapid and vast multiplication of the commodities and conveniences of existence, the general standard of comfort has been raised; the ravages of pestilence and famine have been checked; and the natural obstacles, which time and space offer to mutual intercourse, have been reduced in a manner and to an extent unknown to former ages. The diminution or removal of local ignorance and prejudice, the creation of common interests among the most widely separated peoples, and the strengthening of the forces of the organization of the commonwealth against those of political or social anarchy, thus effected, have exerted an influence on the present and future fortunes of mankind the full significance of which may be divined, but can not as yet be estimated at its full value.

This revolution—for it is nothing less—in the political and social aspects of modern civilization has been preceded, accompanied, and in great measure caused by a less obvious, but no less marvellous, increase of natural knowledge, and especially of that part of it which is known as physical science, in consequence of the application of scientific method to the investigation of the phenomena of the material world. Not that the growth of physical science is an exclusive prerogative of the Victorian age. Its present strength and volume merely indicate the highest level of a stream which took its rise, alongside of the primal founts of Philosophy, Literature, and Art, in ancient Greece; and, after being dammed up for a thousand years, once more began to flow three centuries ago.

### GREEK AND MEDIÆVAL SCIENCE.

It may be doubted if even-handed justice, as free from fulsome panegyric as from captious depreciation, has ever yet been dealt out to the

\* Extracted, by permission, from a collection of historic summaries entitled "The Reign of Queen Victoria: A survey of fifty years of progress. Edited by Thomas Humphry Ward." Two vols., 8vo. London: 1887. Vol. II, pp. 322-387.

sages of antiquity who for eight centuries, from the time of Thales to that of Galen, toiled at the foundations of physical science. But, without entering into the discussion of that large question, it is certain that the labors of these early workers in the field of natural knowledge were brought to a standstill by the decay and disruption of the Roman Empire, the consequent disorganization of society, and the diversion of men's thoughts from sublunary matters to the problems of the supernatural world suggested by Christian dogma in the Middle Ages. And, notwithstanding sporadic attempts to recall men to the investigation of nature here and there, it was not until the fifteenth and sixteenth centuries that physical science made a new start, founding itself at first altogether upon that which had been done by the Greeks. Indeed, it must be admitted that the men of the Renaissance, though standing on the shoulders of the old philosophers, were a long time before they saw as much as their forerunners had done.

The first serious attempts to carry further the unfinished work of Archimedes, Hipparchus, and Ptolemy, of Aristotle and of Galen, naturally enough arose among the astronomers and the physicians. For the imperious necessity of seeking some remedy for the physical ills of life had insured the preservation of more or less of the wisdom of Hippocrates and his successors, and, by a happy conjunction of circumstances, the Jewish and Arabian physicians and philosophers escaped many of the influences which at that time blighted natural knowledge in the Christian world. On the other hand, the superstitious hopes and fears which afforded countenance to astrology and to alchemy also sheltered astronomy and the germs of chemistry. Whether for this or for some better reason the founders of the schools of the Middle Ages included astronomy along with geometry, arithmetic, and music as one of the four branches of advanced education, and in this respect it is only just to them to observe that they were far in advance of those who sit in their seats. The schoolmen considered no one to be properly educated unless he were acquainted with—at any rate—one branch of physical science. We have not even yet reached that stage of enlightenment.

In the early decades of the seventeenth century the men of the Renaissance could show that they had already put out to good interest the treasure bequeathed to them by the Greeks. They had produced the astronomical system of Copernicus, with Kepler's great additions; the astronomical discoveries and the physical investigations of Galileo; the mechanics of Stevinus and the "De Magnete" of Gilbert; the anatomy of the great French and Italian schools and the physiology of Harvey. In Italy, which had succeeded Greece in the hegemony of the scientific world, the Accademia dei Lyncei, and sundry other such associations for the investigation of nature, the models of all subsequent academies and scientific societies, had been founded, while the literary skill and biting wit of Galileo had made the great scientific questions of the day not only intelligible, but attractive, to the general public.

## FRANCIS BACON.

In our own country Francis Bacon had essayed to sum up the past of physical science, and to indicate the path which it must follow if its great destinies were to be fulfilled. And though the attempt was just such a magnificent failure as might have been expected from a man of great endowments, who was so singularly devoid of scientific insight that he could not understand the value of the work already achieved by the true instaurators of physical science, yet the majestic eloquence and the fervid vaticinations of one who was conspicuous alike by the greatness of his rise and the depth of his fall, drew the attention of all the world to the "new birth of Time."

But it is not easy to discover satisfactory evidence that the "Novum Organum" had any direct beneficial influence on the advancement of natural knowledge. No delusion is greater than the notion that method and industry can make up for lack of mother wit, either in science or in practical life, and it is strange that, with his knowledge of mankind, Bacon should have dreamed that his or any other "via inveniendi scientias" would "level men's wits" and leave little scope for that inborn capacity which is called genius. As a matter of fact, Bacon's "via" has proved hopelessly impracticable, while the "Anticipation of Nature," by the invention of hypotheses based on incomplete inductions, which he specially condemns, has proved itself to be a most efficient, indeed an indispensable, instrument of scientific progress. Finally, that transcendental alchemy, the superinducement of new forms on matter, which Bacon declares to be the supreme aim of science, has been wholly ignored by those who have created the physical knowledge of the present day.

Even the eloquent advocacy of the chancellor brought no unmixed good to physical science. It was natural enough that the man who, in his better moments, took "all knowledge for his patrimony," but, in his worse, sold that birthright for the mess of pottage of court favor and professional success, for pomp and show, should be led to attach an undue value to the practical advantages which he foresaw, as Roger Bacon and, indeed, Seneca had foreseen, long before his time, must follow in the train of the advancement of natural knowledge. The burden of Bacon's pleadings for science is the "gathering of fruit"—the importance of winning solid material advantages by the investigation of nature and the desirableness of limiting the application of scientific methods of inquiry to that field.

## THOMAS HOBBS.

Bacon's younger contemporary, Hobbes, casting aside the prudent reserve of his predecessor in regard to those matters about which the Crown or the Church might have something to say, extended scientific methods of inquiry to the phenomena of mind and the problems of



social organization; while, at the same time, he indicated the boundary between the province of real, and that of imaginary, knowledge. The "Principles of Philosophy" and the "Leviathan" embody a coherent system of purely scientific thought in language which is a model of clear and vigorous English style.

#### DESCARTES.

At the same time, in France, a man of far greater scientific capacity than either Bacon or Hobbes, René Descartes, not only in his immortal "Discours de la Méthode" and elsewhere, went down to the foundations of scientific certainty, but, in his "Principes de Philosophie," indicated where the goal of physical science really lay. However, Descartes was an eminent mathematician, and it would seem that the bent of his mind led him to over-estimate the value of deductive reasoning from general principles, as much as Bacon had under-estimated it. The progress of physical science has been effected neither by Baconians nor by Cartesians—as such, but by men like Galileo and Harvey, Boyle and Newton, who would have done their work just as well if neither Bacon nor Descartes had ever propounded his views respecting the manner in which scientific investigation should be pursued.

#### PROGRESS WITHOUT "FRUITS."

The progress of science, during the first century after Bacon's death, by no means verified his sanguine prediction of the fruits which it would yield. For, though the revived and renewed study of nature had spread and grown to an extent which surpassed reasonable expectation, the practical results—the "good to men's estate"—were at first by no means apparent. Sixty years after Bacon's death, Newton had crowned the long labors of the astronomers and the physicists by co-ordinating the phenomena of molar motion throughout the visible universe into one vast system; but the "Principia" helped no man to either wealth or comfort. Descartes, Newton, and Leibnitz had opened up new worlds to the mathematician, but the acquisitions of their genius enriched only man's ideal estate. Descartes had laid the foundations of rational cosmogony and of physiological psychology; Boyle had produced models of experimentation in various branches of physics and chemistry; Pascal and Torricelli had weighed the air; Malpighi and Grew, Ray and Wiloughby had done work of no less importance in the biological sciences; but weaving and spinning were carried on with the old appliances; nobody could travel faster by sea or by land than at any previous time in the world's history, and King George could send a message from London to York no faster than King John might have done. Metals were worked from their ores by immemorial rule of thumb, and the center of the iron trade of these islands was still among the oak forests of Sussex. The utmost skill of our mechanics did not get beyond the production of a coarse watch.

The middle of the eighteenth century is illustrated by a host of great names in science—English, French, German, and Italian,—especially in the fields of chemistry, geology, and biology; but this deepening and broadening of natural knowledge\*produced next to no immediate practical benefits. Even if, at this time, Francis Bacon could have returned to the scene of his greatness and of his littleness, he must have regarded the philosophic world which praised and disregarded his precepts with great disfavor. If ghosts are consistent he would have said, “These people are all wasting their time, just as Gilbert and Kepler and Galileo and my worthy physician Harvey did in my day. Where are the fruits of the restoration of science which I promised? This accumulation of bare knowledge is all very well, but *cui bono*? Not one of these people is doing what I told him specially to do, and seeking that secret of the cause of forms which will enable men to deal at will with matter, and super-induce new natures upon the old foundations.”

#### LATER PRACTICAL EFFECT.

But, a little later, that growth of knowledge beyond imaginable utilitarian ends, which is the condition precedent of its practical utility, began to produce some effect upon practical life; and the operation of that part of nature we call human upon the rest began to create, not “new natures,” in Bacon’s sense, but a new Nature, the existence of which is dependent upon men’s efforts, which is subservient to their wants, and which would disappear if man’s shaping and guiding hand were withdrawn. Every mechanical artifice, every chemically pure substance employed in manufacture, every abnormally fertile race of plants, or rapidly growing and fattening breed of animals, is a part of the new Nature created by science. Without it the most densely populated regions of modern Europe and America must retain their primitive, sparsely inhabited, agricultural or pastoral condition: it is the foundation of our wealth and the condition of our safety from submergence by another flood of barbarous hordes; it is the bond which unites into a solid political whole, regions larger than any empire of antiquity; it secures us from the recurrence of the pestilences and famines of former times; it is the source of endless comforts and conveniences, which are not mere luxuries, but conduce to physical and moral well-being. During the last fifty years, this new birth of time, this new Nature begotten by science upon fact, has pressed itself daily and hourly upon our attention, and has worked miracles which have modified the whole fashion of our lives.

What wonder, then, if these astonishing fruits of the tree of knowledge are too often regarded by both friends and enemies as the be-all and end-all of science? What wonder if some eulogize, and others revile, the new philosophy for its utilitarian ends and its merely material triumphs?

In truth, the new philosophy deserves neither the praise of its eulogists, nor the blame of its slanderers. As I have pointed out, its disciples were guided by no search after practical fruits during the great period of its growth, and it reached adolescence without being stimulated by any rewards of that nature. The bare enumeration of the names of the men who were the great lights of science in the latter part of the eighteenth and the first decade of the nineteenth century, of Herschel, of Laplace, of Young, of Fresnel, of Oersted, of Cavendish, of Lavoisier, of Davy, of Lamarck, of Cuvier, of Jussieu, of Decandolle, of Werner, and of Hutton, suffices to indicate the strength of physical science in the age immediately preceding that of which I have to treat. But of which of these great men can it be said that his labors were directed to practical ends? I do not call to mind even an invention of practical utility which we owe to any of them, except the safety-lamp of Davy. Werner certainly paid attention to mining, and I have not forgotten James Watt. But, though some of the most important of the improvements by which Watt converted the steam-engine, invented long before his time, into the obedient slave of man, were suggested and guided by his acquaintance with scientific principles, his skill as a practical mechanic and the efficiency of Bolton's workmen had quite as much to do with the realization of his projects.

#### LOVE OF KNOWLEDGE.

In fact, the history of physical science teaches (and we can not too carefully take the lesson to heart) that the practical advantages, attainable through its agency, never have been, and never will be, sufficiently attractive to men inspired by the inborn genius of the interpreter of nature, to give them courage to undergo the toils and make the sacrifices which that calling requires from its votaries. That which stirs their pulses is the love of knowledge and the joy of the discovery of the causes of things sung by the old poets; the supreme delight of extending the realm of law and order ever farther towards the unattainable goals of the infinitely great and the infinitely small, between which our little race of life is run. In the course of this work, the physical philosopher, sometimes intentionally, much more often unintentionally, lights upon something which proves to be of practical value. Great is the rejoicing of those who are benefited thereby; and, for the moment, science is the Diana of all the craftsmen. But, even while the cries of jubilation resound, and this flotsam and jetsam of the tide of investigation is being turned into the wages of workmen and the wealth of capitalists, the crest of the wave of scientific investigation is far away on its course over the illimitable ocean of the unknown.

#### SCIENCE AND INDUSTRY RECIPROCALLY DEPENDENT.

Far be it from me to depreciate the value of the gifts of science to practical life, or to cast a doubt upon the propriety of the course of ac-



tion of those who follow science in the hope of finding wealth alongside truth, or even wealth alone. Such a profession is as respectable as any other. And quite as little do I desire to ignore the fact that, if industry owes a heavy debt to science, it has largely repaid the loan by the important aid which it has, in its turn, rendered to the advancement of science. In considering the causes which hindered the progress of physical knowledge in the schools of Athens and of Alexandria, it has often struck me\* that where the Greeks did wonders was in just those branches of science, such as geometry, astronomy, and anatomy, which are susceptible of very considerable development without any, or any but the simplest, appliances. It is a curious speculation to think what would have become of modern physical science if glass and alcohol had not been easily obtainable; and if the gradual perfection of mechanical skill for industrial ends had not enabled investigators to obtain, at comparatively little cost, microscopes, telescopes, and all the exquisitely delicate apparatus for determining weight and measure and for estimating the lapse of time with exactness, which they now command. If science has rendered the colossal development of modern industry possible, beyond a doubt industry has done no less for modern physics and chemistry, and for a great deal of modern biology. And as the captains of industry have at last begun to be aware that the condition of success in that warfare, under the forms of peace, which is known as industrial competition lies in the discipline of the troops and the use of arms of precision, just as much as it does in the warfare which is called war, their demand for that discipline, which is technical education, is re-acting upon science in a manner which will assuredly stimulate its future growth to an incalculable extent. It has become obvious that the interests of science and of industry are identical; that science can not make a step forward without sooner or later opening up new channels for industry, and on the other hand, that every advance of industry facilitates those experimental investigations upon which the growth of science depends. We may hope that at last the weary misunderstanding between the practical men who professed to despise science, and the high and dry philosophers who professed to despise practical results, is at an end.

Nevertheless, that which is true of the infancy of physical science in the Greek world, that which is true of its adolescence in the seventeenth and eighteenth centuries, remains true of its riper age in these latter days of the nineteenth century. The great steps in its progress have been made, are made, and will be made, by men who seek knowledge simply because they crave it. They have their weaknesses, their follies, their vanities, and their rivalries, like the rest of the world; but whatever by-ends may mar their dignity and impede their usefulness, this

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\* There are excellent remarks to the same effect in Zeller's *Philosophie der Griechen*, Theil II, Abth. II, p. 407, and in Eucken's *Die Methode der Aristotelischen, Forschung*, pp. 138 *et seq.*



chief end redeems them.\* Nothing great in science has ever been done by men, whatever their powers, in whom the divine afflatus of the truth-seeker was wanting. Men of moderate capacity have done great things because it animated them; and men of great natural gifts have failed, absolutely or relatively, because they lacked this one thing needful.

#### TRUE OBJECT OF RESEARCH.

To any one who knows the business of investigation practically, Bacon's notion of establishing a company of investigators to work for "fruits," as if the pursuit of knowledge were a kind of mining operation and only required well directed picks and shovels, seems very strange.† In science, as in art, and, as I believe, in every other sphere of human activity, there may be wisdom in a multitude of counsellors, but it is only in one or two of them. And in scientific inquiry at any rate, it is to that one or two that we must look for light and guidance. Newton said that he made his discoveries by "intending" his mind on the subject; no doubt truly. But to equal his success one must have the mind which he "intended." Forty lesser men might have intended their minds till they cracked, without any like result. It would be idle either to affirm or to deny that the last half century has produced men of science of the caliber of Newton. It is sufficient that it can show a few capacities of the first rank, competent not only to deal profitably with the inheritance bequeathed by their scientific forefathers, but to pass on to their successors physical truths of a higher order than any yet reached by the human race. And if they have succeeded as Newton succeeded, it is because they have sought truth as he sought it, with no other object than the finding it.

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#### PROGRESS FROM 1837 TO 1887.

I am conscious that in undertaking to give even the briefest sketch of the progress of physical science, in all its branches, during the last

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\* Fresnel, after a brilliant career of discovery in some of the most difficult regions of physico-mathematical science, died at thirty-nine years of age. The following passage of a letter from him to Young (written in November, 1824), quoted by Whewell, so aptly illustrates the spirit which animates the scientific inquirer, that I may cite it:

"For a long time that sensibility, or that vanity, which people call love of glory is much blunted in me. I labor much less to catch the suffrages of the public than to obtain an inward approval which has always been the mental reward of my efforts. Without doubt I have often wanted the spur of vanity to excite me to pursue my researches in moments of disgust and discouragement. But all the compliments which I have received from MM. Arago, De Laplace, or Biot, never gave me so much pleasure as the discovery of a theoretical truth or the confirmation of a calculation by experiment."

† "Mémorable exemple de l'impuissance des recherches collectives appliquées à la découverte des vérités nouvelles," says one of the most distinguished of living French savants, of the corporate chemical work of the old Académie des Sciences. (See Berthelot, *Science et Philosophie*, p. 201.)

half century, I may be thought to have exhibited more courage than discretion, and perhaps more presumption than either. So far as physical science is concerned, the days of Admirable Orichtons have long been over, and the most indefatigable of hard workers may think he has done well if he has mastered one of its minor subdivisions. Nevertheless, it is possible for any one who has familiarized himself with the operations of science in one department, to comprehend the significance, and even to form a general estimate of the value, of the achievements of specialists in other departments.

Nor is there any lack either of guidance, or of aids to ignorance. By a happy chance, the first edition of Whewell's "History of the Inductive Sciences" was published in 1837, and it affords a very useful view of the state of things at the commencement of the Victorian epoch. As to subsequent events, there are numerous excellent summaries of the progress of various branches of science, especially up to 1881, which was the jubilee year of the British Association.\* And, with respect to the biological sciences, with some parts of which my studies have familiarized me, my personal experience nearly coincides with the preceding half century. I may hope therefore that my chance of escaping serious errors is as good as that of any one else who might have been persuaded to undertake the somewhat perilous enterprise in which I find myself engaged.

There is yet another prefatory remark which it seems desirable I should make. It is that I think it proper to confine myself to the work done, without saying anything about the doers of it. Meddling with questions of merit and priority is a thorny business at the best of times, and, unless in case of necessity, altogether undesirable when one is dealing with contemporaries. No such necessity lies upon me; and I shall therefore mention no names of living men, lest perchance I should incur the reproof which the Israelites, who struggled with one another in the field, addressed to Moses, "Who made thee a prince and a judge over us?"

#### AIM OF PHYSICAL SCIENCE.

Physical science is one and indivisible. Although for practical purposes it is convenient to mark it out into the primary regions of Physics Chemistry, and Biology, and to subdivide these into subordinate provinces, yet the method of investigation and the ultimate object of the physical inquirer are everywhere the same.

The object is the discovery of the rational order which pervades the universe; the method consists of observation and experiment (which is observation under artificial conditions) for the determination of the

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\* I am particularly indebted to my friend and colleague Professor Rücker, F. R. S., for the many acute criticisms and suggestions on my remarks respecting the ultimate problems of physics, with which he has favored me, and by which I have greatly profited.

facts of nature, of inductive and deductive reasoning for the discovery of their mutual relations and connection. The various branches of physical science differ in the extent to which, at any given moment of their history, observation on the one hand, or ratiocination on the other, is their more obvious feature, but in no other way; and nothing can be more incorrect than the assumption one sometimes meets with, that physics has one method, chemistry another, and biology a third.

#### POSTULATES.

All physical science starts from certain postulates. One of them is the objective existence of a material world. It is assumed that the phenomena which are comprehended under this name have a "substratum" of extended, impenetrable, mobile substance, which exhibits the quality known as inertia, and is termed matter.\* Another postulate is the universality of the law of causation; that nothing happens without a cause (that is, a necessary precedent condition), and that the state of the physical universe, at any given moment, is the consequence of its state at any preceding moment. Another is that any of the rules, or so-called "laws of nature," by which the relation of phenomena is truly defined, is true for all time. The validity of these postulates is a problem of metaphysics; they are neither self-evident nor are they, strictly speaking, demonstrable. The justification of their employment, as axioms of physical philosophy, lies in the circumstance that expectations logically based upon them are verified, or, at any rate, not contradicted, whenever they can be tested by experience.

#### HYPOTHESES.

Physical science therefore rests on verified or uncontradicted hypotheses; and such being the case, it is not surprising that a great condition of its progress has been the invention of verifiable hypotheses. It is a favorite popular delusion that the scientific inquirer is under a sort of moral obligation to abstain from going beyond that generalization of observed facts which is absurdly called "Baconian" induction. But any one who is practically acquainted with scientific work is aware

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\* I am aware that this proposition may be challenged. It may be said, for example, that, on the hypothesis of Roscovich, matter has no extension, being reduced to mathematical points serving as centers of "forces." But as the "forces" of the various centers are conceived to limit one another's action in such a manner that an area around each center has an individuality of its own, extension comes back in the form of that area. Again, a very eminent mathematician and physicist, the late Clerk Maxwell, has declared that impenetrability is not essential to our notions of matter, and that two atoms may conceivably occupy the same space. I am loth to dispute any dictum of a philosopher as remarkable for the subtlety of his intellect as for his vast knowledge; but the assertion that one and the same point or area of space can have different (conceivably opposite) attributes appears to me to violate the principle of contradiction, which is the foundation not only of physical science, but of logic in general. It means that A can be not-A.



that those who refuse to go beyond fact rarely get as far as fact; and any one who has studied the history of science knows that almost every great step therein has been made by the "anticipation of nature," that is, by the invention of hypotheses, which though verifiable, often had very little foundation to start with; and not unfrequently, in spite of a long career of usefulness, turned out to be wholly erroneous in the long run.

#### HYPOTHESES FRUITFUL EVEN WHEN ERRONEOUS.

The geocentric system of astronomy, with its eccentrics and its epicycles, was an hypothesis utterly at variance with fact, which nevertheless did great things for the advancement of astronomical knowledge. Kepler was the wildest of guessers. Newton's corpuscular theory of light was of much temporary use in optics, though nobody now believes in it; and the undulatory theory, which has superseded the corpuscular theory, and has proved one of the most fertile of instruments of research, is based on the hypothesis of the existence of an "æther," the properties of which are defined in propositions, some of which, to ordinary apprehension, seem physical antinomies.

It sounds paradoxical to say that the attainment of scientific truth has been effected, to a great extent, by the help of scientific errors. But the subject-matter of physical science is furnished by observation, which can not extend beyond the limits of our faculties; while, even within those limits, we can not be certain that any observation is absolutely exact and exhaustive. Hence it follows that any given generalization from observation may be true, within the limits of our powers of observation at a given time, and yet turn out to be untrue, when those powers of observation are directly or indirectly enlarged. Or, to put the matter in another way, a doctrine which is untrue absolutely, may to a very great extent be susceptible of an interpretation in accordance with the truth. At a certain period in the history of astronomical science the assumption that the planets move in circles was true enough to serve the purpose of correlating such observations as were then possible; after Kepler, the assumption that they move in ellipses became true enough in regard to the state of observational astronomy at that time. We say still that the orbits of the planets are ellipses, because, for all ordinary purposes, that is a sufficiently near approximation to the truth; but, as a matter of fact, the center of gravity of a planet describes neither an ellipse nor any other simple curve, but an immensely complicated undulating line. It may fairly be doubted whether any generalization, or hypothesis, based upon physical data is absolutely true, in the sense that a mathematical proposition is so; but, if its errors can become apparent only outside the limits of practicable observation, it may be just as usefully adopted for one of the symbols of that algebra by which we interpret nature, as if it were absolutely true.

The development of every branch of physical knowledge presents



three stages which, in their logical relation, are successive. The first is the determination of the sensible character and order of the phenomena. This is *Natural History*, in the original sense of the term, and here nothing but observation and experiment avail us. The second is the determination of the constant relations of the phenomena thus defined, and their expression in rules or laws. The third is the explication of these particular laws by deduction from the most general laws of matter and motion. The last two stages constitute *Natural Philosophy* in its original sense. In this region, the invention of verifiable hypotheses is not only permissible, but is one of the conditions of progress.

Historically, no branch of science has followed this order of growth; but, from the dawn of exact knowledge to the present day, observation, experiment, and speculation have gone hand in hand; and, whenever science has halted or strayed from the right path, it has been, either because its votaries have been content with mere unverified or unverifiable speculation (and this is the commonest case, because observation and experiment are hard work, while speculation is amusing); or it has been because the accumulation of details of observation has for a time excluded speculation.

The progress of physical science, since the revival of learning, is largely due to the fact that men have gradually learned to lay aside the consideration of unverifiable hypotheses; to guide observation and experiment by verifiable hypotheses; and to consider the latter, not as ideal truths, the real entities of an intelligible world behind phenomena, but as a symbolical language, by the aid of which nature can be interpreted in terms apprehensible by our intellects. And if physical science, during the last fifty years, has attained dimensions beyond all former precedent, and can exhibit achievements of greater importance than any former such period can show, it is because able men, animated by the true scientific spirit, carefully trained in the method of science, and having at their disposal immensely improved appliances, have devoted themselves to the enlargement of the boundaries of natural knowledge in greater number than during any previous half century of the world's history.

### THREE GREAT RECENT ACHIEVEMENTS.

I have said that our epoch can produce achievements in physical science of greater moment than any other has to show, advisedly; and I think that there are three great products of our time which justify the assertion. One of these is that doctrine concerning the constitution of matter, which, for want of a better name, I will call "molecular;" the second is the doctrine of conservation of energy; the third is the doctrine of evolution. Each of these was foreshadowed, more or less distinctly, in former periods of the history of science; and, so far is either from being the outcome of purely inductive reasoning, that it would be hard to over-rate the influence of metaphysical, and even of theological,

considerations upon the development of all three. The peculiar merit of our epoch is that it has shown how these hypotheses connect a vast number of seemingly independent partial generalizations; that it has given them that precision of expression which is necessary for their exact verification; and that it has practically proved their value as guides to the discovery of new truth. All three doctrines are intimately connected, and each is applicable to the whole physical cosmos. But, as might have been expected from the nature of the case, the first two grew, mainly, out of the consideration of physico-chemical phenomena while the third, in great measure, owes its rehabilitation, if not its origin, to the study of biological phenomena.

### 1. STRUCTURE OF MATTER.

In the early decades of this century, a number of important truths applicable, in part, to matter in general, and, in part, to particular forms of matter, had been ascertained by the physicists and chemists.

The laws of motion of visible and tangible—or *molar* matter had been worked out to a great degree of refinement and embodied in the branches of science known as Mechanics, Hydrostatics, and Pneumatics. These laws had been shown to hold good, so far as they could be checked by observation and experiment, throughout the universe, on the assumption that all such masses of matter possessed inertia and were susceptible of acquiring motion in two ways, firstly by impact, or impulse from without; and secondly, by the operation of certain hypothetical causes of motion termed “forces,” which were usually supposed to be resident in the particles of the masses themselves, and to operate at a distance, in such a way as to tend to draw any two such masses together, or to separate them more widely.

With respect to the ultimate constitution of these masses, the same two antagonistic opinions which had existed since the time of Democritus and of Aristotle were still face to face. According to the one, matter was discontinuous and consisted of minute indivisible particles or atoms, separated by a universal vacuum; according to the other, it was continuous, and the finest distinguishable, or imaginable, particles were scattered through the attenuated general substance of the plenum. A rough analogy to the latter case would be afforded by granules of ice diffused through water; to the former, such granules diffused through absolutely empty space.

In the latter part of the eighteenth century the chemists had arrived at several very important generalizations respecting those properties of matter with which they were especially concerned. However plainly ponderable matter seemed to be originated and destroyed in their operations, they proved that as mass or body, it remained indestructible, and ingenerable; and that so far, it varied only in its perceptibility by our senses. The course of investigation further proved that a certain number of the chemically separable kinds of matter were

unalterable by any known means (except in so far as they might be made to change their state from solid to fluid, or *vice versa*), unless they were brought into contact with other kinds of matter, and that the properties of these several kinds of matter were always the same, whatever their origin. All other bodies were found to consist of two or more of these, which thus took the place of the four "elements" of the ancient philosophers. Further, it was proved that in forming chemical compounds, bodies always unite in a definite proportion by weight, or in simple multiples of that proportion, and that, if any one body were taken as a standard, every other could have a number assigned to it as its proportional combining weight. It was on this foundation of fact that Dalton based his re-establishment of the old atomic hypothesis on a new empirical foundation. It is obvious that if elementary matter consists of indestructible and indivisible particles, each of which constantly preserves the same weight relatively to all the others, compounds formed by the aggregation of two, three, four, or more such particles must exemplify the rule of combination in definite proportions deduced from observation.

In the meanwhile, the gradual reception of the undulatory theory of light necessitated the assumption of the existence of an "æther" filling all space. But whether this æther was to be regarded as a strictly material and continuous substance was an undecided point, and hence the revived atomism escaped strangling in its birth. For it is clear that if the æther is admitted to be a continuous material substance, Democritic atomism is at an end, and Cartesian continuity takes its place.

The real value of the new atomic hypothesis, however, did not lie in the two points which Democritus and his followers would have considered essential, namely, the indivisibility of the "atoms" and the presence of an inter-atomic vacuum; but in the assumption that, to the extent to which our means of analysis take us, material bodies consist of definite minute masses, each of which, so far as physical and chemical processes of division go, may be regarded as a unit—having a practically permanent individuality. Just as a man is the unit of sociology, without reference to the actual fact of his divisibility, so such a minute mass is the unit of physico-chemical science—that smallest material particle which under any given circumstances acts as a whole.\*

The doctrine of specific heat originated in the eighteenth century. It means that the same mass of a body, under the same circumstances, always requires the same quantity of heat to raise it to a given temperature, but that equal masses of different bodies require different quantities. Ultimately, it was found that the quantities of heat required to raise equal masses of the more perfect gases through equal ranges of temperature were inversely proportional to their combining weights.

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\* "Molecule" would be the more appropriate name for such a particle. Unfortunately chemists employ this term in a special sense as a name for an aggregation of their smallest particles, for which they retain the designation of "atoms."



and heat. The phenomena of electrolytic decomposition showed that there was a like close relation between these units and electricity. The quantity of electricity generated by the combination of any two units is sufficient to separate any other two which are susceptible of such decomposition. The phenomena of isomorphism showed a relation between the units and crystalline forms; certain units are thus able to replace others in a crystalline body without altering its form, and others are not.

Again, the laws of the effect of pressure and heat on gaseous bodies, the fact that they combine in definite proportions by volume, and that such proportion bears a simple relation to their combining weights, all harmonized with the Daltonian hypothesis, and led to the bold speculation known as the law of Avogadro—that all gaseous bodies, under the same physical conditions, contain the same number of units. In the form in which it was first enunciated this hypothesis was incorrect—perhaps it is not exactly true in any form; but it is hardly too much to say that chemistry and molecular physics would never have advanced to their present condition unless it had been assumed to be true. Another immense service rendered by Dalton, as a corollary of the new atomic doctrine, was the creation of a system of symbolic notation, which not only made the nature of chemical compounds and processes easily intelligible and easy of recollection, but, by its very form, suggested new lines of inquiry. The atomic notation was as serviceable to chemistry as the binomial nomenclature and the classificatory schematism of Linnæus were to zoology and botany.

Side by side with these advances arose another, which also has a close parallel in the history of biological science. If the unit of a compound is made up by the aggregation of elementary units, the notion that these must have some sort of definite arrangement inevitably suggests itself; and such phenomena as double decomposition pointed, not only to the existence of a molecular architecture, but to the possibility of modifying a molecular fabric without destroying it, by taking out some of the component units and replacing them by others. The class of neutral salts, for example, includes a great number of bodies in many ways similar, in which the basic molecules, or the acid molecules, may be replaced by other basic and other acid molecules without altering the neutrality of the salt; just as a cube of bricks remains a cube so long as any brick that is taken out is replaced by another of the same shape and dimensions, whatever its weight or other properties may be. Facts of this kind gave rise to the conception of “types” of molecular structure, just as the recognition of the unity in diversity of the structure of the species of plants and animals gave rise to the notion of biological “types.” The notation of chemistry enabled these ideas to be represented with precision; and they acquired an immense importance when the improvement of methods of analysis, which took place about



Thus a definite relation was established between the hypothetical units the beginning of our period, enabled the composition of the so-called "organic" bodies to be determined with rapidity and precision.\* A large proportion of these compounds contain not more than three or four elements, of which carbon is the chief; but their number is very great, and the diversity of their physical and chemical properties is astonishing. The ascertainment of the proportion of each element in these compounds affords little or no help towards accounting for their diversities; widely different bodies being often very similar, or even identical, in that respect. And, in the last case, that of *isomeric* compounds, the appeal to diversity of arrangement of the identical component units was the only obvious way out of the difficulty. Here again hypothesis proved to be of great value; not only was the search for evidence of diversity of molecular structure successful, but the study of the process of taking to pieces led to the discovery of the way to put together, and vast numbers of compounds, some of them previously known only as products of the living economy, have thus been artificially constructed. Chemical work at the present day is, to a large extent, synthetic or creative; that is to say, the chemist determines, theoretically, that certain non-existent compounds ought to be producible, and he proceeds to produce them.

It is largely because the chemical theory and practice of our epoch have passed into this deductive and synthetic stage, that they are entitled to the name of the "New Chemistry," which they commonly receive. But this new chemistry has grown up by the help of hypotheses, such as these of Dalton, and of Avogadro, and that singular conception of "bonds" invented to colligate the facts of "valency" or "atomicity," the first of which took some time to make its way; while the second fell into oblivion for many years after it was propounded for lack of empirical justification. As for the third, it may be doubted if any one regards it as more than a temporary contrivance.

But some of these hypotheses have done yet further service. Combining them with the mechanical theory of heat and the doctrine of the conservation of energy, which are also products of our time, physicists have arrived at an entirely new conception of the nature of gaseous bodies and of the relation of the physico-chemical units of matter to the different forms of energy. The conduct of gases under varying pressure and temperature, their diffusibility, their relation to radiant heat and to light, the evolution of heat when bodies combine, the absorption of heat when they are dissociated, and a host of other molecular phenomena, have been shown to be deducible from the dynamical and statical principles which apply to molar motion and rest; and the tendency of the physico-chemical science is clearly towards the reduction of the problems of the world of the infinitely little, as it already

\* "At present more organic analyses are made in a single day than were accomplished before Liebig's time in a whole year."—Hofmann, Faraday Lecture, p. 46.

has reduced those of the infinitely great world, to questions of mechanics.\*

In the meanwhile, the primitive atomic theory, which has served as the scaffolding for the edifice of modern physics and chemistry, has been quietly dismissed. I can not discover that any contemporary physicist or chemist believes in the real indivisibility of atoms, or in an inter-atomic matterless vacuum. "Atoms" appear to be used as mere names for physico-chemical units which have not yet been subdivided, and "molecules" for physico-chemical units which are aggregates of the former. And these individualized particles are supposed to move in an endless ocean of a vastly more subtle matter—the æther. If this æther is a continuous substance, therefore, we have got back from the hypothesis of Dalton to that of Descartes. But there is much reason to believe that science is going to make a still further journey, and in form, if not altogether in substance, to return to the point of view of Aristotle.

The greater number of the so-called "elementary" bodies, now known, had been discovered before the commencement of our epoch; and it had become apparent that they were by no means equally similar or dissimilar, but that some of them, at any rate, constituted groups, the several members of which were as much like one another as they were unlike the rest. Chlorine, iodine, bromine, and fluorine thus formed a very distinct group; sulphur and selenium another; boron and silicon another; potassium, sodium, and lithium another, and so on. In some cases the atomic weights of such allied bodies were nearly the same, or could be arranged in series, with like differences between the several terms. In fact, the elements afforded indications that they were susceptible of a classification in natural groups, such as those into which animals and plants fall.

#### PERIODIC SERIES OF ELEMENTS.

Recently this subject has been taken up afresh, with a result which may be stated roughly in the following terms: If the sixty-five or sixty-eight recognized "elements" are arranged in the order of their atomic weights—from hydrogen, the lightest, as unity, to uranium, the heaviest, as 240—the series does not exhibit one continuous progressive modification in the physical and chemical characters of its several terms, but breaks up into a number of sections, in each of which the several terms present analogies with the corresponding terms of the other series.

Thus the whole series does not run

$a, b, c, d, e, f, g, h, i, k, \text{etc.},$

but

$a, b, c, d, A, B, C, D, a, \beta, \gamma, \delta, \text{etc.};$

so that it is said to express a *periodic law* of recurrent similarities. Or

\* In the preface to his *Mécanique*, Chimique M. Berthelot declares his object to be "ramener la chimie tout entière - - - aux émmes principes mécaniques qui régissent déjà les diverses branches de la physique."

the relation may be expressed in another way. In each section of the series, the atomic weight is greater than in the preceding section, so that if  $w$  is the atomic weight of any element in the first segment,  $w + x$  will represent the atomic weight of any element in the next, and  $w + x + y$  the atomic weight of any element in the next, and so on. Therefore the sections may be represented as parallel series, the corresponding terms of which have analogous properties; each successive series starting with a body the atomic weight of which is greater than that of any in the preceding series, in the following fashion:

$d$	D	$\delta$
$c$	C	$\gamma$
$b$	B	$\beta$
$a$	A	$\alpha$
<hr/>	<hr/>	<hr/>
$w$	$w + x$	$w + x + y$

This is a conception with which biologists are very familiar, animal and plant groups constantly appearing as series of parallel modifications of similar and yet different primary forms. In the living world, facts of this kind are now understood to mean evolution from a common prototype. It is difficult to imagine that in the not-living world they are devoid of significance. Is it not possible, nay probable, that they may mean the evolution of our "elements" from a primary undifferentiated form of matter? Fifty years ago such a suggestion would have been scouted as a revival of the dreams of the alchemists. At present it may be said to be the burning question of physico-chemical science.

In fact, the so-called "vortex-ring" hypothesis is a very serious and remarkable attempt to deal with material units from a point of view which is consistent with the doctrine of evolution. It supposes the æther to be a uniform substance, and that the "elementary" units are, broadly speaking, permanent whirlpools, or vortices, of this æther, the properties of which depend on their actual and potential modes of motion. It is curious and highly interesting to remark that this hypothesis reminds us not only of the speculations of Descartes, but of those of Aristotle. The resemblance of the "vortex-rings" to the "tourbillons" of Descartes is little more than nominal; but the correspondence between the modern and the ancient notion of a distinction between primary and derivative matter is, to a certain extent, real. For this ætherial "Urstoff" of the modern, corresponds very closely with the *πρώτη ὑλη* of Aristotle, the *materia prima* of his mediæval followers; while matter, differentiated into our elements, is the equivalent of the first stage of progress towards the *ἐσχάτη ὑλη*, or finished matter, of the ancient philosophy.

If the material units of the existing order of nature are specialized portions of a relatively homogeneous *materia prima*—which were originated under conditions that have long ceased to exist and which remain unchanged and unchangeable under all conditions, whether natural or



artificial, hitherto known to us—it follows that the speculation that they may be indefinitely altered, or that new units may be generated under conditions yet to be discovered, is perfectly legitimate. Theoretically, at any rate, the transmutability of the elements is a verifiable scientific hypothesis; and such inquiries as those which have been set afoot, into the possible dissociative action of the great heat of the sun upon our elements, are not only legitimate, but are likely to yield results which, whether affirmative or negative, will be of great importance. The idea that atoms are absolutely ingenerable and immutable “manufactured articles” stands on the same sort of foundation as the idea that biological species are “manufactured articles” stood thirty years ago; and the supposed constancy of the elementary atoms, during the enormous lapse of time measured by the existence of our universe, is of no more weight against the possibility of change in them, in the infinity of antecedent time, than the constancy of species in Egypt, since the days of Rameses or Cheops, is evidence of their immutability during all past epochs of the earth’s history. It seems safe to prophesy that the hypothesis of the evolution of the elements from a primitive matter will, in future, play no less a part in the history of science than the atomic hypothesis, which, to begin with, had no greater if so great an empirical foundation.

It may perhaps occur to the reader that the boasted progress of physical science does not come to much, if our present conceptions of the fundamental nature of matter are expressible in terms employed, more than two thousand years ago, by the old “master of those that know.” Such a criticism, however, would involve forgetfulness of the fact that the connotation of these terms, in the mind of the modern, is almost infinitely different from that which they possessed in the mind of the ancient philosopher. In antiquity, they meant little more than vague speculation; at the present day they indicate definite physical conceptions, susceptible of mathematical treatment, and giving rise to innumerable deductions, the value of which can be experimentally tested. The old notions produced little more than floods of dialectics; the new are powerful aids towards the increase of solid knowledge.

## 2. CONSERVATION OF ENERGY.

Every-day observation shows that of the bodies which compose the material world, some are in motion and some are, or appear to be, at rest. Of the bodies in motion, some, like the sun and stars, exhibit a constant movement, regular in amount and direction, for which no external cause appears. Others, as stones and smoke, seem also to move of themselves when external impediments are taken away; but these appear to tend to move in opposite directions, the bodies we call heavy, such as stones, downwards, and the bodies we call light, at least such as smoke and steam, upwards; and as we further notice that the earth below our feet is made up of heavy matter, while the air above our



heads is extremely light matter, it is easy to regard this fact as evidence that the lower region is the place to which heavy things tend—their proper place, in short—while the upper region is the proper place of light things; and to generalize the facts observed by saying that bodies which are free to move tend towards their proper places. All these seem to be natural motions, dependent on the inherent faculties or tendencies of bodies themselves; but there are other motions which are artificial or violent, as when a stone is thrown from the hand or is knocked by another stone in motion. In such cases as these, for example, when a stone is cast from the hand the distance travelled by the stone appears to depend partly on its weight and partly upon the exertion of the thrower. So that the weight of the stone remaining the same, it looks as if the motive power communicated to it were measured by the distance to which the stone travels;—as if (in other words) the power needed to send it a hundred yards was twice as great as that needed to send it fifty yards. These, apparently obvious, conclusions from the every-day appearances of rest and motion fairly represent the state of opinion upon the subject which prevailed among the ancient Greeks and remained dominant until the age of Galileo. The publication of the “*Principia*” of Newton in 1686-’87 marks the epoch at which the progress of mechanical physics had effected a complete revolution of thought on these subjects. By this time it had been made clear that the old generalizations were either incomplete or totally erroneous; that a body, once set in motion, will continue to move in a straight line for any conceivable time or distance, unless it is interfered with; that any change of motion is proportional to the “force” which causes it and takes place in the direction in which that “force” is exerted, and that when a body in motion acts as a cause of motion on another the latter gains as much as the former loses, and *vice versa*. It is to be noted, however, that while, in contradistinction to the ancient idea of the inherent tendency to motion of bodies, the absence of any such spontaneous power of motion was accepted as a physical axiom by the moderns, the old conception virtually maintained itself in a new shape. For, in spite of Newton’s well-known warning against the “absurdity” of supposing that one body can act on another at a distance through a vacuum, the ultimate particles of matter were generally assumed to be the seats of perennial causes of motion termed “attractive and repulsive forces,” in virtue of which any two such particles, without any external impression of motion or intermediate material agent, were supposed to tend to approach or remove from one another; and this view of the duality of the causes of motion is very widely held at the present day.

Another important result of investigation, attained in the seventeenth century, was the proof and quantitative estimation of physical inertia. In the old philosophy, a curious conjunction of ethical and physical prejudices had led to the notion that there was something ethically bad and physically obstructive about matter. Aristotle attributes all irregu-

larities and apparent dysteleologies in nature to the disobedience, or sluggish yielding, of matter to the shaping and guiding influence of those reasons and causes which were hypostatized in his ideal "Forms." In modern science, the conception of the inertia, or resistance to change, of matter is complex. In part, it contains a corollary from the law of causation: A body can not change its state in respect of rest or motion without a sufficient cause. But, in part, it contains generalizations from experience. One of these is that there is no such cause resident in any body, and that therefore it will rest or continue in motion so long as no external cause of change acts upon it. The other is that the effect which the impact of a body in motion produces upon the body on which it impinges depends, other things being alike, on the relation of a certain quality of each which is called "mass." Given a cause of motion of a certain value, the amount of motion, measured by distance travelled in a certain time, which it will produce in a given quantity of matter, say a cubic inch, is not always the same, but depends on what that matter is;—a cubic inch of iron will go faster than a cubic inch of gold. Hence, it appears, that since equal amounts of motion have, *ex hypothesi*, been produced, the amount of motion in a body does not depend on its speed alone, but on some property of the body. To this the name of "mass" has been given. And since it seems reasonable to suppose that a large quantity of matter, moving slowly, possesses as much motion as a small quantity moving faster, "mass" has been held to express "quantity of matter." It is further demonstrable that, at any given time and place, the relative mass of any two bodies is expressed by the ratio of their weights.

When all these great truths respecting molar motion, or the movements of visible and tangible masses, had been shown to hold good not only of terrestrial bodies, but of all those which constitute the visible universe, and the movements of the macrocosm had thus been expressed by a general mechanical theory, there remained a vast number of phenomena, such as those of light, heat, electricity, magnetism, and those of the physical and chemical changes, which do not involve molar motion. Newton's corpuscular theory of light was an attempt to deal with one great series of these phenomena on mechanical principles, and it maintained its ground until, at the beginning of the nineteenth century, the undulatory theory proved itself to be a much better working hypothesis. Heat, up to that time, and indeed much later, was regarded as an imponderable substance, *caloric*; as a thing which was absorbed by bodies when they were warmed, and was given out as they cooled; and which, moreover, was capable of entering into a sort of chemical combination with them, and so becoming latent. Rumford and Davy had given a great blow to this view of heat by proving that the quantity of heat which two portions of the same body could be made to give out, by rubbing them together, was practically illimitable. This result brought philosophers face to face with the contradiction of supposing that a

finite body could contain an infinite quantity of another body; but it was not until 1843, that clear and unquestionable experimental proof was given of the fact that there is a definite relation between mechanical work and heat; that so much work always gives rise, under the same conditions, to so much heat, and so much heat to so much mechanical work. Thus originated the mechanical theory of heat, which became the starting point of the modern doctrine of the conservation of energy. Molar motion had appeared to be destroyed by friction. It was proved that no destruction took place, but that an exact equivalent of the energy of the lost molar motion appears as that of the *molecular* motion, or motion of the smallest particles of a body, which constitutes heat. The loss of the masses is the gain of their particles.

Before 1843, however, the doctrine of the conservation of energy had been approached. Bacon's chief contribution to positive science is the happy guess (for the context shows that it was little more) that heat may be a mode of motion; Descartes affirmed the quantity of motion in the world to be constant; Newton nearly gave expression to the complete theorem, while Rumford's and Davy's experiments suggested, though they did not prove, the equivalency of mechanical and thermal energy. Again, the discovery of voltaic electricity, and the marvellous development of knowledge in that field, effected by such men as Davy, Faraday, Oersted, Ampère, and Melloni, had brought to light a number of facts which tended to show that the so-called "forces" at work in light, heat, electricity, and magnetism, in chemical and in mechanical operations, were intimately, and in various cases, quantitatively related. It was demonstrated that any one could be obtained at the expense of any other; and apparatus was devised which exhibited the evolution of all these kinds of action from one source of energy. Hence the idea of the "correlation of forces" which was the immediate forerunner of the doctrine of the conservation of energy.

It is a remarkable evidence of the greatness of the progress in this direction which has been effected in our time, that even the second edition of the "History of the Inductive Sciences," which was published in 1846, contains no allusion either to the general view of the "Correlation of Forces" published in England in 1842, or to the publication in 1843 of the first of the series of experiments by which the mechanical equivalent of heat was correctly ascertained.\* Such a failure on the part of a

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\*This is the more curious, as Ampère's hypothesis that vibrations of molecules, causing and caused by vibrations of the æther constitute heat, is discussed. See vol. ii, p. 587, 2d ed. In the *Philosophy of the Inductive Sciences*, 2d ed., 1847, p. 239, Whewell remarks *à propos* of Bacon's definition of heat, "that it is an expansive, restrained motion, modified in certain ways, and exerted in the smaller particles of the body;" that "although the exact nature of heat is still an obscure and controverted matter, the science of heat now consists of many important truths; and that to none of these truths is there any approximation in Bacon's essay." In point of fact, Bacon's statement, however much open to criticism, does contain a distinct approximation to the most important of all the truths respecting heat which had been discovered when Whewell wrote.



contemporary, of great acquirements and remarkable intellectual powers, to read the signs of the times, is a lesson and a warning worthy of being deeply pondered by any one who attempts to prognosticate the course of scientific progress.

I have pointed out that the growth of clear and definite views respecting the constitution of matter has led to the conclusion that so far as natural agencies are concerned, it is ingenerable and indestructible. In so far as matter may be conceived to exist in a purely passive state, it is, imaginably, older than motion. But as it must be assumed to be susceptible of motion, a particle of bare matter at rest must be endowed with the potentiality of motion. Such a particle however, by the supposition can have no energy, for there is no cause why it should move. Suppose now that it receives an impulse, it will begin to move with a velocity inversely proportional to its mass on the one hand, and directly proportional to the strength of the impulse on the other, and will possess *kinetic energy*, in virtue of which it will not only continue to move forever if unimpeded, but if it impinges on another such particle it will impart more or less of its motion to the latter. Let it be conceived that the particle acquires a tendency to move, and that nevertheless it does not move. It is then in a condition totally different from that in which it was at first. A cause competent to produce motion is operating upon it, but, for some reason or other, is unable to give rise to motion. If the obstacle is removed, the energy which was there but could not manifest itself, at once gives rise to motion. While the restraint lasts, the energy of the particle is merely potential; and the case supposed illustrates what is meant by *potential energy*. In this contrast of the potential with the actual, modern physics is turning to account the most familiar of Aristotelian distinctions—that between *δύναμις* and *ἐνέργεια*.

That kinetic energy appears to be imparted by impact is a fact of daily and hourly experience: we see bodies set in motion by bodies, already in motion, which seem to come into contact with them. It is a truth which could have been learned by nothing but experience, and which can not be explained, but must be taken as an ultimate fact about which, explicable or inexplicable, there can be no doubt. Strictly speaking, we have no direct apprehension of any other cause of motion. But experience furnishes innumerable examples of the production of kinetic energy in a body previously at rest, when no impact is discernible as the cause of that energy. In all such cases, the presence of a second body is a necessary condition; and the amount of kinetic energy, which its presence enables the first to gain, is strictly dependent on the relative positions of the two. Hence the phrase *energy of position*, which is frequently used as equivalent to potential energy. If a stone is picked up and held, say, 6 feet above the ground, it has *potential energy*, because, if let go, it will immediately begin to move towards the earth; and this energy may be said to be *energy of position*, because it depends upon the relative position of the earth and the stone. The



stone is solicited to move, but can not so long as the muscular strength of the holder prevents the solicitation from taking effect. The stone, therefore, has potential energy, which becomes kinetic if it is let go, and the amount of that kinetic energy which will be developed before it strikes the earth depends upon its position,—on the fact that it is, say, 6 feet off the earth, neither more nor less. Moreover, it can be proved that the raiser of the stone had to exert as much energy in order to place it in its position as it will develop in falling. Hence the energy which was exerted, and apparently exhausted, in raising the stone is potentially in the stone in its raised position, and will manifest itself when the stone is set free. Thus the energy, withdrawn from the general stock to raise the stone, is returned when it falls, and there is no change in the total amount. Energy, as a whole, is conserved.

Taking this as a very broad and general statement of the essential facts of the case, the raising of the stone is intelligible enough, as a case of the communication of motion from one body to another. But the potential energy of the raised stone is not so easily intelligible. To all appearance, there is nothing either pushing or pulling it toward the earth, or the earth toward it; and yet it is quite certain that the stone tends to move toward the earth, and the earth toward the stone, in the way defined by the law of gravitation.

In the currently accepted language of science, the cause of motion, in all such cases as this, when bodies tend to move toward or away from one or another, without any discernible impact of other bodies, is termed a "force," which is called "attractive" in the one case, and "repulsive" in the other. And such attractive or repulsive forces are often spoken of as if they were real things, capable of exerting a pull, or a push, upon the particles of matter concerned. Thus the potential energy of the stone is commonly said to be due to the "force" of gravity which is continually operating upon it.

Another illustration may make the case plainer. The bob of a pendulum swings first to one side and then to the other of the center of the arc which it describes. Suppose it to have just reached the summit of its right-hand half-swing. It is said that the "attractive forces" of the bob for the earth, and of the earth for the bob, set the former in motion; and as these "forces" are continually in operation, they confer an accelerated velocity on the bob; until, when it reaches the center of its swing, it is, so to speak, fully charged with kinetic energy. If, at this moment, the whole material universe, except the bob, were abolished, it would move forever in the direction of a tangent to the middle of the arc described. As a matter of fact, it is compelled to travel through its left-hand half-swing, and thus virtually to go up hill. Consequently the "attractive forces" of the bob and the earth are now acting against it, and constitute a resistance which the charge of kinetic energy has to overcome. But as this charge represents the operation of the attractive forces, during the passage of the bob through the right-hand half-swing

down to the center of the arc, so it must needs be used up by the passage of the bob upward from the center of the arc to the summit of the left-hand half swing. Hence, at this point, the bob comes to a momentary rest. The last fraction of kinetic energy is just neutralized by the action of the attractive forces, and the bob has only potential energy equal to that with which it started. So that the sum of the phenomena may be stated thus: At the summit of either half-arc of its swing, the bob has a certain amount of potential energy; and as it descends it gradually exchanges this for kinetic energy, until at the center it possesses an equivalent amount of kinetic energy; from this point onwards, it gradually loses kinetic energy as it ascends, until, at the summit of the other half-arc, it has required an exactly similar amount of potential energy. Thus, on the whole transaction, nothing is either lost or gained; the quantity of energy is always the same, but it passes from one form into the other.

To all appearance, the phenomena exhibited by the pendulum are not to be accounted for by impact; in fact, it is usually assumed that corresponding phenomena would take place if the earth and the pendulum were situated in an absolute vacuum, and at any conceivable distance from one another. If this be so, it follows that there must be two totally different kinds of causes of motion; the one impact—a *vera causa*, of which, to all appearance, we have constant experience; the other, attractive or repulsive “force”—a metaphysical entity which is physically inconceivable. Newton expressly repudiated the notion of the existence of attractive forces, in the sense in which that term is ordinarily understood; and he refused to put forward any hypothesis as to the physical cause of the so-called “attraction of gravitation.” As a general rule, his successors have been content to accept the doctrine of attractive and repulsive forces, without troubling themselves about the philosophical difficulties which it involves. But this has not always been the case; and the attempt of Le Sage, in the last century, to show that the phenomena of attraction and repulsion are susceptible of explanation by his hypothesis of bombardment by ultra-mundane particles, whether tenable or not, has the great merit of being an attempt to get rid of the dual conception of the causes of motion which has hitherto prevailed. On this hypothesis, the hammering of the ultra-mundane corpuscles on the bob confers its kinetic energy on the one hand, and takes it away on the other; and the state of potential energy means the condition of the bob during the instant at which the energy conferred by the hammering during the one half-arc has just been exhausted by the hammering during the other half-arc. It seems safe to look forward to the time when the conception of attractive and repulsive forces, having served its purpose as a useful piece of scientific scaffolding, will be replaced by the deduction of the phenomena known as attraction and repulsion, from the general laws of motion.

The doctrine of the conservation of energy, which I have endeavored to illustrate, is thus defined by the late Clerk Maxwell:

"The total energy of any body or system of bodies is a quantity which can neither be increased nor diminished by any mutual action of such bodies, though it may be transformed into any one of the forms of which energy is susceptible." It follows that energy, like matter, is indestructible and ingenerable in nature. The phenomenal world, so far as it is material, expresses the evolution and involution of energy, its passage from the kinetic to the potential condition and back again. Wherever motion of matter takes place, that motion is effected at the expense of part of the total store of energy.

Hence, as the phenomena exhibited by living beings, in so far as they are material, are all molar or molecular motions, these are included under the general law. A living body is a machine by which energy is transformed in the same sense as a steam-engine is so, and all its movements, molar and molecular, are to be accounted for by the energy which is supplied to it. The phenomena of consciousness which arise, along with certain transformations of energy, can not be interpolated in the series of these transformations, inasmuch as they are not motions to which the doctrine of the conservation of energy applies. And for the same reason, they do not necessitate the using up of energy; a sensation has no mass and can not be conceived to be susceptible of movement. That a particular molecular motion does give rise to a state of consciousness is experimentally certain; but the how and why of the process are just as inexplicable as in the case of the communication of kinetic energy by impact.

When dealing with the doctrine of the ultimate constitution of matter, we found a certain resemblance between the oldest speculations and the newest doctrines of physical philosophers. But there is no such resemblance between the ancient and modern views of motion and its causes, except in so far as the conception of attractive and repulsive forces may be regarded as the modified descendant of the Aristotelian conception of forms. In fact, it is hardly too much to say that the essential and fundamental difference between ancient and modern physical science lies in the ascertainment of the true laws of statics and dynamics in the course of the last three centuries; and in the invention of mathematical methods of dealing with all the consequences of these laws. The ultimate aim of modern physical science is the deduction of the phenomena exhibited by material bodies from physico-mathematical first principles. Whether the human intellect is strong enough to attain the goal set before it may be a question, but thither will it surely strive.

### 3. EVOLUTION.

The third great scientific event of our time, the rehabilitation of the doctrine of evolution, is part of the same tendency of increasing knowl-



edge to unify itself, which has led to the doctrine of the conservation of energy. And this tendency, again, is mainly a product of the increasing strength conferred by physical investigation on the belief in the universal validity of that orderly relation of facts, which we express by the so-called "Laws of Nature."

The growth of a plant from its seed, of an animal from its egg, the apparent origin of innumerable living things from mud, or from the putrefying remains of former organisms, had furnished the earlier scientific thinkers with abundant analogies suggestive of the conception of a corresponding method of cosmic evolution from a formless "chaos" to an ordered world which might either continue forever or undergo dissolution into its elements before starting on a new course of evolution. It is therefore no wonder that, from the days of the Ionian school onwards, the view that the universe was the result of such a process should have maintained itself as a leading dogma of philosophy. The emanistic theories which played so great a part in Neoplatonic philosophy and Gnostic theology are forms of evolution. In the seventeenth century, Descartes propounded a scheme of evolution, as an hypothesis of what might have been the mode of origin of the world, while professing to accept the ecclesiastical scheme of creation, as an account of that which actually was its manner of coming into existence. In the eighteenth century Kant put forth a remarkable speculation as to the origin of the solar system, closely similar to that subsequently adopted by Laplace and destined to become famous under the title of the "nebular hypothesis."

The careful observations and the acute reasonings of the Italian geologists of the seventeenth and eighteenth centuries, the speculations of Leibnitz in the "*Protogæa*" and of Buffon in his "*Théorie de la Terre*," the sober and profound reasonings of Hutton, in the latter part of the eighteenth century,—all these tended to show that the fabric of the earth itself implied the continuance of processes of natural causation for a period of time as great, in relation to human history, as the distances of the heavenly bodies from us are, in relation to terrestrial standards of measurement. The abyss of time began to loom as large as the abyss of space. And this revelation to sight and touch, of a link here and a link there of a practically infinite chain of natural causes and effects, prepared the way, as perhaps nothing else has done, for the modern form of the ancient theory of evolution.

In the beginning of the eighteenth century, De Maillet made the first serious attempt to apply the doctrine to the living world. In the latter part of it, Erasmus Darwin, Goethe, Treviranus, and Lamarck, took up the work more vigorously and with better qualifications. The question of special creation, or evolution, lay at the bottom of the fierce disputes which broke out in the French Academy between Cuvier and St.-Hilaire; and, for a time, the supporters of biological evolution were silenced, if not answered, by the alliance of the greatest naturalist of



the age with their ecclesiastical opponents. Catastrophism, a short-sighted teleology, and a still more short-sighted orthodoxy, joined forces to crush evolution.

Lyell and Poulett Scrope, in this country, resumed the work of the Italians and of Hutton; and the former, aided by a marvellous power of clear exposition, placed upon an irrefragable basis the truth that natural causes are competent to account for all events, which can be proved to have occurred, in the course of the secular changes which have taken place during the deposition of the stratified rocks. The publication of "The Principles of Geology," in 1830, constituted an epoch in geological science. But it also constituted an epoch in the modern history of the doctrines of evolution, by raising in the mind of every intelligent reader this question: If natural causation is competent to account for the not-living part of our globe, why should it not account for the living part?

By keeping this question before the public for some thirty years, Lyell, though the keenest and most formidable of the opponents of the transmutation theory, as it was formulated by Lamarck, was of the greatest possible service in facilitating the reception of the sounder doctrines of a later day. And in like fashion, another vehement opponent of the transmutation of species, the elder Agassiz, was doomed to help the cause he hated. Agassiz not only maintained the fact of the progressive advance in organization of the inhabitants of the earth at each successive geological epoch, but he insisted upon the analogy of the steps of this progression with those by which the embryo advances to the adult condition, among the highest forms of each group. In fact, in endeavoring to support these views he went a good way beyond the limits of any cautious interpretation of the facts then known.

Although little acquainted with biological science, Whewell seems to have taken particular pains with that part of his work which deals with the history of geological and biological speculation; and several chapters of his seventeenth and eighteenth books, which comprise the history of physiology, of comparative anatomy and of the palætiological sciences, vividly reproduce the controversies of the early days of the Victorian epoch. But here, as in the case of the doctrine of the conservation of energy, the historian of the inductive sciences has no prophetic insight; not even a suspicion of that which the near future was to bring forth. And those who still repeat the once favorite objection that Darwin's "Origin of Species" is nothing but a new version of the "Philosophie zoologique" will find that, so late as 1844, Whewell had not the slightest suspicion of Darwin's main theorem, even as a logical possibility. In fact, the publication of that theorem by Darwin and Wallace, in 1859, took all the biological world by surprise. Neither those who were inclined towards the "progressive transmutation" or "development" doctrine, as it was then called, nor those who were opposed to it, had the slightest suspicion that the tendency to variation

in living beings, which all admitted as a matter of fact, the selective influence of conditions, which no one could deny to be a matter of fact when his attention was drawn to the evidence, and the occurrence of great geological changes which also was matter of fact, could be used as the only necessary postulates of a theory of the evolution of plants and animals which, even if not, at once, competent to explain all the known facts of biological science, could not be shown to be inconsistent with any. So far as biology is concerned, the publication of the "Origin of Species," for the first time, put the doctrine of evolution, in its application to living things, upon a sound scientific foundation. It became an instrument of investigation, and in no hands did it prove more brilliantly profitable than in those of Darwin himself. His publications on the effects of domestication in plants and animals, on the influence of cross-fertilization, on flowers as organs for effecting such fertilization, on insectivorous plants, on the motions of plants, pointed out the routes of exploration which have since been followed by hosts of inquirers, to the great profit of science.

Darwin found the biological world a more than sufficient field for even his great powers, and left the cosmical part of the doctrine to others. Not much has been added to the nebular hypothesis since the time of Laplace, except that the attempt to show (against that hypothesis) that all nebulae are star clusters, has been met by the spectroscopic proof of the gaseous condition of some of them. Moreover, physicists of the present generation appear now to accept the secular cooling of the earth, which is one of the corollaries of that hypothesis. In fact, attempts have been made, by the help of deductions from the data of physics, to lay down an approximate limit to the number of millions of years which have elapsed since the earth was habitable by living beings. If the conclusions thus reached should stand the test of further investigation, they will undoubtedly be very valuable. But, whether true or false, they can have no influence upon the doctrine of evolution in its application to living organisms. The occurrence of successive forms of life upon our globe is an historical fact which can not be disputed, and the relation of these successive forms, as stages of evolution of the same type, is established in various cases. The biologist has no means of determining the time over which the process of evolution has extended, but accepts the computation of the physical geologist and the physicist, whatever that may be.

Evolution as a philosophical doctrine applicable to all phenomena, whether physical or mental, whether manifested by material atoms or by men in society, has been dealt with systematically in the "Synthetic Philosophy" of Mr. Herbert Spencer. Comment on that great undertaking would not be in place here. I mention it because, so far as I know, it is the first attempt to deal on scientific principles with modern scientific facts and speculations. For the "Philosophie positive" of M. Comte, with which Mr. Spencer's system of philosophy is sometimes

compared, though it professes a similar object, is unfortunately permeated by a thoroughly unscientific spirit, and its author had no adequate acquaintance with the physical sciences even of his own time.

The doctrine of evolution, so far as the present physical cosmos is concerned, postulates the fixity of the rules of operation of the causes of motion in the material universe. If all kinds of matter are modifications of one kind, and if all modes of motion are derived from the same energy, the orderly evolution of physical nature out of one substratum and one energy implies that the rules of action of that energy should be fixed and definite. In the past history of the universe back to that point, there can be no room for chance or disorder. But it is possible to raise the question whether this universe of simplest matter and definitely operating energy, which forms our hypothetical starting point, may not itself be a product of evolution from a universe of such matter, in which the manifestations of energy were not definite,—in which, for example, our laws of motion held good for some units and not for others, or for the same units at one time and not at another,—and which would therefore be a real epicurean chance-world?

For myself, I must confess that I find the air of this region of speculation too rarefied for my constitution, and I am disposed to take refuge in "*ignoramus et ignorabimus*."

#### OTHER SCIENTIFIC ACHIEVEMENTS.

The execution of my further task, the indication of the most important achievements in the several branches of physical science during the last fifty years, is embarrassed by the abundance of the objects of choice; and by the difficulty which every one, but a specialist in each department, must find in drawing a due distinction between the discoveries which strike the imagination by their novelty, or by their practical influence, and those unobtrusive but pregnant observations and experiments in which the germs of the great things of the future really lie. Moreover, my limits restrict me to little more than a bare chronicle of the events which I have to notice.

In physics and chemistry, the old boundaries of which sciences are rapidly becoming effaced, one can hardly go wrong in ascribing a primary value to the investigations into the relation between the solid, liquid, and gaseous states of matter on the one hand, and degrees of pressure and of heat on the other. Almost all, even the most refractory, solids have been vaporized by the intense heat of the electric arc; and the most refractory gases have been forced to assume the liquid, and even the solid, forms by the combination of high pressure with intense cold. It has further been shown that there is no discontinuity between these states—that a gas passes into the liquid state through a condition which is neither one nor the other, and that a liquid body becomes solid, or a solid liquid, by the intermediation of a condition in which it is neither truly solid nor truly liquid.



## KINETIC THEORY OF GASES.

Theoretical and experimental investigations have concurred in the establishment of the view that a gas is a body, the particles of which are in incessant rectilinear motion at high velocities, colliding with one another and bounding back when they strike the walls of the containing vessel; and, on this theory, the already ascertained relations of gaseous bodies to heat and pressure have been shown to be deducible from mechanical principles. Immense improvements have been effected in the means of exhausting a given space of its gaseous contents; and experimentation on the phenomena which attend the electric discharge and the action of radiant heat, within the extremely rarefied media thus produced, has yielded a great number of remarkable results, some of which have been made familiar to the public by the Gieseler tubes and the radiometer. Already these investigations have afforded an unexpected insight into the constitution of matter and its relations with thermal and electric energy, and they open up a vast field for future inquiry into some of the deepest problems of physics. Other important steps, in the same direction, have been effected by investigations into the absorption of radiant heat proceeding from different sources by solid, fluid, and gaseous bodies. And it is a curious example of the inter-connection of the various branches of physical science, that some of the results thus obtained have proved of great importance in meteorology.

## SPECTROSCOPY.

The existence of numerous dark lines, constant in their number and position in the various regions of the solar spectrum, was made out by Fraunhofer in the early part of the present century, but more than forty years elapsed before their causes were ascertained and their importance recognized. Spectroscopy, which then took its rise, is probably that employment of physical knowledge, already won, as a means of further acquisition, which most impresses the imagination. For it has suddenly and immensely enlarged our power of overcoming the obstacles which almost infinite minuteness on the one hand, and almost infinite distance on the other, have hitherto opposed to the recognition of the presence and the condition of matter. One eighteen-millionth of a grain of sodium in the flame of a spirit-lamp may be detected by this instrument; and, at the same time, it gives trustworthy indications of the material constitution not only of the sun, but of the farthest of those fixed stars and nebulae which afford sufficient light to affect the eye, or the photographic plate, of the inquirer.\*

## ELECTRICAL ADVANCES.

The mathematical and experimental elucidation of the phenomena of electricity, and the study of the relations of this form of energy with



chemical and thermal action, had made extensive progress before 1837. But the determination of the influence of magnetism on light, the discovery of diamagnetism, of the influence of crystalline structure on magnetism, and the completion of the mathematical theory of electricity, all belong to the present epoch. To it also appertain the practical execution and the working out of the results of the great international system of observations on terrestrial magnetism, suggested by Humboldt in 1836; and the invention of instruments of infinite delicacy and precision for the quantitative determination of electrical phenomena. The voltaic battery has received vast improvements; while the invention of magneto-electric engines and of improved means of producing ordinary electricity has provided sources of electrical energy vastly superior to any before extant in power, and far more convenient for use.

It is perhaps this branch of physical science which may claim the palm for its practical fruits, no less than for the aid which it has furnished to the investigation of other parts of the field of physical science. The idea of the practicability of establishing a communication between distant points, by means of electricity, could hardly fail to have simmered in the minds of ingenious men, since well-nigh a century ago, experimental proof was given that electric disturbances could be propagated through a wire 12,000 feet long. Various methods of carrying the suggestion into practice had been effected with some degree of success; but the system of electric telegraphy, which, at the present time, brings all parts of the civilized world within a few minutes of one another, originated only about the commencement of the epoch under consideration. In its influence on the course of human affairs, this invention takes its place beside that of gunpowder, which tended to abolish the physical inequalities of fighting men,—of printing, which tended to destroy the effect of inequalities in wealth among learning men,—of steam transport, which has done the like for travelling men. All these gifts of science are aids in the process of levelling up; of removing the ignorant and baneful prejudices of nation against nation, province against province, and class against class; of assuring that social order which is the foundation of progress, which has redeemed Europe from barbarism, and against which one is glad to think that those who, in our time, are employing themselves in fanning the embers of ancient wrong, in setting class against class, and in trying to tear asunder the existing bonds of unity, are undertaking a futile struggle. The telephone is only second in practical importance to the electric telegraph. Invented, as it were, only the other day, it has already taken its place as an appliance of daily life. Sixty years ago the extraction of metals from their solutions, by the electric current, was simply a highly interesting scientific fact. At the present day the galvano-plastic art is a great industry; and, in combination with photography, promises to be of endless service in the arts. Electric

lighting is another great gift of science to civilization, the practical effects of which have not yet been fully developed, largely on account of its cost. But those whose memories go back to the tinder-box period, and recollect the cost of the first lucifer matches, will not despair of the results of the application of science and ingenuity to the cheap production of anything for which there is a large demand.

The influence of the progress of electrical knowledge and invention upon that of investigation in other fields of science is highly remarkable. The combination of electrical with mechanical contrivances has produced instruments by which not only may extremely small intervals of time be exactly measured, but the varying rapidity of movements, which take place in such intervals and appear to the ordinary sense instantaneous, is recorded. The duration of the winking of an eye is a proverbial expression for an instantaneous action; but, by the help of the revolving cylinder and the electrical-marking apparatus, it is possible to obtain a graphic record of such an action, in which, if it endures a fraction of a second, that fraction shall be subdivided into a hundred or a thousand equal parts, and the state of the action at each hundredth or thousandth of a second exhibited. In fact, these instruments may be said to be time-microscopes. Such appliances have not only effected a revolution in physiology by the power of analyzing the phenomena of muscular and nervous activity which they have conferred, but they have furnished new methods of measuring the rate of movement of projectiles to the artillerist. Again, the microphone, which renders the minutest movements audible, and which enables a listener to hear the footfall of a fly, has equipped the sense of hearing with the means of entering almost as deeply into the penetralia of nature as does the sense of sight.

#### PHOTOGRAPHY.

That light exerts a remarkable influence in bringing about certain chemical combinations and decompositions was well known fifty years ago, and various more or less successful attempts to produce permanent pictures by the help of that knowledge had already been made. It was not till 1839, however, that practical success was obtained; but the "daguerreotypes" were both cumbrous and costly, and photography would never have attained its present important development had not the progress of invention substituted paper and glass for the silvered plates then in use. It is not my affair to dwell upon the practical application of the photography of the present day, but it is germane to my purpose to remark that it has furnished a most valuable accessory to the methods of recording motions and lapse of time already in existence. In the hands of the astronomer and the meteorologist it has yielded means of registering terrestrial, solar, planetary, and stellar phenomena, independent of the sources of error attendant on ordinary observation; in the hands of the physicist not only does it record spectroscopic phenomena with unsurpassable ease and precision, but it has

revealed the existence of rays having powerful chemical energy, or beyond the visible limits of either end of the spectrum; while, to the naturalist, it furnishes the means by which the forms of many highly complicated objects may be represented, without that possibility of error which is inherent in the work of the draughtsman. In fact, in many cases, the stern impartiality of photography is an objection to its employment,—it makes no distinction between the important and the unimportant; and hence photographs of dissections, for example, are rarely so useful as the work of a draughtsman who is at once accurate and intelligent.

#### ASTRONOMY.

The determination of the existence of a new planet, Neptune, far beyond the previously known bounds of the solar system, by mathematical deduction from the facts of perturbation; and the immediate confirmation of that determination, in the year 1846, by observers who turned their telescopes into the part of the heavens indicated as its place, constitute a remarkable testimony of nature to the validity of the principles of the astronomy of our time. In addition, so many new asteroids have been added to those which were already known to circulate in the place which theoretically should be occupied by a planet, between Mars and Jupiter, that their number now amounts to between two and three hundred. I have already alluded to the extension of our knowledge of the nature of the heavenly bodies by the employment of spectroscopy. It has not only thrown wonderful light upon the physical and chemical constitution of the sun, fixed stars, and nebulae and comets, but it holds out a prospect of obtaining definite evidence as to the nature of our so-called elementary bodies.

#### ASTRONOMIC GEOLOGY.

The application of the generalizations of thermotics to the problem of the duration of the earth, and of deductions from tidal phenomena to the determination of the length of the day and of the time of revolution of the moon, in past epochs of the history of the universe; and the demonstration of the competency of the great secular changes, known under the general name of the precession of the equinoxes, to cause corresponding modifications in the climate of the two hemispheres of our globe, have brought astronomy into intimate relation with geology. Geology, in fact, proves that in the course of the past history of the earth, the climatic conditions of the same regions have been widely different, and seeks the explanation of this important truth from the sister sciences. The facts that, in the middle of the Tertiary epoch, evergreen trees abounded within the arctic circle; and that, in the long subsequent Quaternary epoch, an arctic climate, with its accompaniment of gigantic glaciers, obtained in the northern hemisphere, as far south as Switzerland and central France, are as well established as any truths



of science. But, whether the explanation of these extreme variations in the mean temperature of a great part of the northern hemisphere is to be sought in the concomitant changes in the distribution of land and water surfaces of which geology affords evidence, or in astronomical conditions, such as those to which I have referred, is a question which must await its answer from the science of the future.

#### BIOLOGY.

Turning now to the great steps in that vast progress which the biological sciences have made since 1837, we are met, on the threshold of our epoch, with perhaps the greatest of all,—namely, the promulgation by Schwann, in 1839, of the generalization known as the “cell theory,” the application and extension of which by a host of subsequent investigators has revolutionized morphology, development, and physiology. Thanks to the immense series of labors thus inaugurated, the following fundamental truths have been established :

All living bodies contain substances of closely similar physical and chemical composition, which constitute the physical basis of life, known as protoplasm. So far as our present knowledge goes, this takes its origin only from pre-existing protoplasm.

All complex living bodies consist, at one period of their existence, of an aggregate of minute portions of such substance, of similar structure, called cells, each cell having its own life independent of the others, though influenced by them.

All the morphological characters of animals and plants are the results of the mode of multiplication, growth, and structural metamorphosis of these cells, considered as morphological units.

All the physiological activities of animals and plants—assimilation, secretion, excretion, motion, generation—are the expression of the activities of the cells considered as physiological units. Each individual, among the higher animals and plants, is a synthesis of millions of subordinate individualities. Its individuality, therefore, is that of a “*civitas*” in the ancient sense, or that of the *Leviathan* of Hobbes.

There is no absolute line of demarkation between animals and plants. The intimate structure, and the modes of change, in the cells of the two are fundamentally the same. Moreover, the higher forms are evolved from lower, in the course of their development, by analogous processes of differentiation, coalescence, and reduction in both the vegetable and the animal worlds.

At the present time the cell theory, in consequence of recent investigations into the structure and metamorphosis of the “nucleus,” is undergoing a new development of great significance, which, among other things, foreshadows the possibility of the establishment of a physical theory of heredity, on a safer foundation than those which Buffon and Darwin have devised.



The popular belief in abiogenesis, or the so-called "spontaneous" generation of the lower forms of life, which was accepted by all the philosophers of antiquity, held its ground down to the middle of the seventeenth century. Notwithstanding the frequent citation of the phrase, wrongfully attributed to Harvey, "*Omne vivum ex ovo*," that great physiologist believed in spontaneous generation as firmly as Aristotle did. And it was only in the latter part of the seventeenth century that Redi, by simple and well-devised experiments, demonstrated that in a great number of cases of supposed spontaneous generation, the animals which made their appearance owed their origin to the ordinary process of reproduction, and thus shook the ancient doctrine to its foundations. In the middle of the eighteenth century it was revived in a new form, by Needham and Buffon; but the experiments of Spallanzani enforced the conclusions of Redi, and compelled the advocates of the occurrence of spontaneous generation to seek evidence for their hypothesis only among the parasites and the lowest and minutest organisms. It is just fifty years since Schwann and others proved that even with respect to them, the supposed evidence of abiogenesis was untrustworthy.

During the present epoch the question whether living matter can be produced in any other way than by the physiological activity of other living matter has been discussed afresh with great vigor; and the problem has been investigated by experimental methods of a precision and refinement unknown to previous investigators. The result is that the evidence in favor of abiogenesis has utterly broken down in every case which has been properly tested. So far as the lowest and minutest organisms are concerned, it has been proved that they never make their appearance if those precautions by which their germs are certainly excluded are taken. And, in regard to parasites, every case which seemed to make for their generation from the substance of the animal or plant which they infest has been proved to have a totally different significance. Whether not-living matter may pass, or ever has under any conditions passed into living matter, without the agency of pre-existing living matter, necessarily remains an open question; all that can be said is that it does not undergo this metamorphosis under any known conditions. Those who take a monistic view of the physical world may fairly hold abiogenesis as a pious opinion, supported by analogy and defended by our ignorance. But, as matters stand, it is equally justifiable to regard the physical world as a sort of dual monarchy. The kingdoms of living matter and of not-living matter are under one system of laws, and there is a perfect freedom of exchange and transit from one to the other. But no claim to biological nationality is valid except birth.

In the department of anatomy and development a host of accurate and patient inquirers, aided by novel methods of preparation, which enable the anatomist to exhaust the details of visible structure and to reproduce them with geometrical precision, have investigated every

important group of living animals and plants, no less than the fossil relics of former faunæ and floræ. An enormous addition has thus been made to our knowledge, especially of the lower forms of life, and it may be said that morphology, however inexhaustible in detail, is complete in its broad features. Classification, which is merely a convenient summary expression of morphological facts, has undergone a corresponding improvement. The breaks which formerly separated our groups from one another, as animals from plants, vertebrates from invertebrates, cryptogams from phanerogams, have either been filled up or shown to have no theoretical significance. The question of the position of man, as an animal, has given rise to much disputation, with the result of proving that there is no anatomical or developmental character by which he is more widely distinguished from the group of animals most nearly allied to him, than they are from one another. In fact, in this particular, the classification of Linnæus has been proved to be more in accordance with the facts than those of most of his successors.

#### ANTHROPOLOGY.

The study of man, as a genus and species of the animal world, conducted with reference to no other considerations than those which would be admitted by the investigator of any other form of animal life, has given rise to a special branch of biology known as Anthropology, which has grown with great rapidity. Numerous societies devoted to this portion of science have sprung up, and the energy of its devotees has produced a copious literature. The physical characters of the various races of men have been studied with a minuteness and accuracy heretofore unknown; and demonstrative evidence of the existence of human contemporaries of the extinct animals of the latest geological epoch has been obtained; physical science has thus been brought into the closest relation with history and with archæology; and the striking investigations which, during our time, have put beyond doubt the vast antiquity of Babylonian and Egyptian civilization, are in perfect harmony with the conclusions of anthropology as to the antiquity of the human species.

Classification is a logical process which consists in putting together those things which are like and keeping asunder those which are unlike; and a morphological classification, of course, takes notes only of morphological likeness and unlikeness. So long, therefore, as our morphological knowledge was almost wholly confined to anatomy, the characters of groups were solely anatomical; but as the phenomena of embryology were explored, the likeness and unlikeness of individual development had to be taken into account; and at present, the study of ancestral evolution introduces a new element of likeness and unlikeness which is not only eminently deserving of recognition, but must ultimately predominate over all others. A classification which shall represent the process of ancestral evolution is, in fact, the end which

the labors of the philosophical taxonomist must keep in view. But it is an end which can not be attained until the progress of palæontology has given us far more insight than we yet possess into the historical facts of the case. Much of the speculative "phylogeny," which abounds among my present contemporaries, reminds me very forcibly of the speculative morphology, unchecked by a knowledge of development, which was rife in my youth. As hypothesis, suggesting inquiry in this or that direction, it is often extremely useful; but when the product of such speculation is placed on a level with those generalizations of morphological truths which are represented by the definitions of natural groups, it tends to confuse fancy with fact and to create mere disorder. We are in danger of drifting into a new "Natur-Philosophie" worse than the old, because there is less excuse for it. Boyle did great service to science by his "Sceptical Chemist," and I am inclined to think that at the present day a "Sceptical Biologist" might exert an equally beneficent influence.

#### PHYSIOLOGY.

Whoso wishes to gain a clear conception of the progress of physiology since 1837, will do well to compare Müller's "Physiology," which appeared in 1835, and Drapiez's edition of Richard's "Nouveaux Eléments de Botanique," published in 1837, with any of the present hand-books of animal and vegetable physiology. Müller's work was a masterpiece, unsurpassed since the time of Haller, and Richard's book enjoyed a great reputation at the time; but their successors transport one into a new world. That which characterizes the new physiology, is that it is permeated by, and indeed based upon conceptions which, though not wholly absent, are but dawning on the minds of the older writers.

Modern physiology sets forth as its chief ends: Firstly, the ascertainment of the facts and conditions of cell-life in general. Secondly, in composite organisms, the analysis of the functions of organs into those of the cells of which they are composed. Thirdly, the explication of the processes by which this local cell-life is directly or indirectly controlled and brought into relation with the life of the rest of the cells which compose the organism. Fourthly, the investigation of the phenomena of life in general, on the assumption that the physical and chemical processes which take place in the living body are of the same order as those which take place out of it; and that whatever energy is exerted in producing such phenomena is derived from the common stock of energy in the universe. In the fifth place modern physiology investigates the relation between physical and psychical phenomena, on the assumption that molecular changes in definite portions of nervous matter stand in the relation of necessary antecedents to definite mental states and operations. The work which has been done in each of the directions here indicated is vast, and the accumulation of solid knowledge, which has been effected, is correspondingly great. For the first time in the



history of science, physiologists are now in the position to say that they have arrived at clear and distinct, though by no means complete, conceptions of the manner in which the great functions of assimilation, respiration, secretion, distribution of nutriment, removal of waste products, motion, sensation, and reproduction are performed; while the operation of the nervous system, as a regulative apparatus, which influences the origination and the transmission of manifestations of activity, either within itself or in other organs, has been largely elucidated.

I have pointed out, in an earlier part of this chapter, that the history of all branches of science proves that they must attain a considerable stage of development before they yield practical "fruits;" and this is eminently true of physiology. It is only within the present epoch that physiology and chemistry have reached the point at which they could offer a scientific foundation to agriculture, and it is only within the present epoch that zoology and physiology have yielded any very great aid to pathology and hygiene. But within that time they have already rendered highly important services by the exploration of the phenomena of parasitism. Not only have the history of the animal parasites, such as the tapeworms and the trichina, which infest men and animals, with deadly results, been cleared up by means of experimental investigations, and efficient modes of prevention deduced from the data so obtained, but the terrible agency of the parasitic fungi and of the infinitesimally minute microbes, which work far greater havoc among plants and animals, has been brought to light. The "particulate" or "germ" theory of disease, as it is called, long since suggested, has obtained a firm foundation, in so far as it has been proved to be true in respect of sundry epidemic disorders. Moreover, it has theoretically justified prophylactic measures, such as vaccination, which formerly rested on a merely empirical basis; and it has been extended to other diseases with excellent results. Further, just as the discovery of the cause of scabies proved the absurdity of many of the old prescriptions for the prevention and treatment of that disease, so the discovery of the cause of splenic fever, and other such maladies, has given a new direction to prophylactic and curative measures against the worst scourges of humanity. Unless the fanaticism of phylloxeric sentiment overpowers the voice of philanthropy, and the love of dogs and cats supersedes that of one's neighbor, the progress of experimental physiology and pathology will indubitably, in course of time, place medicine and hygiene upon a rational basis. Two centuries ago England was devastated by the plague; cleanliness and common sense were enough to free us from its ravages. One century since small-pox was almost as great a scourge; science, though working empirically, and almost in the dark, has reduced that evil to relative insignificance. At the present time, science working in the light of clear knowledge, has attacked splenic fever and has beaten it. It is attacking hydrophobia with no mean promise of success; sooner or later it will deal in the



same way with diphtheria, typhoid and scarlet fever. To one who has seen half a street swept clear of its children, or has lost his own by these horrible pestilences, passing one's offspring through the fire to Moloch seems humanity compared with the proposal to deprive them of half their chances of health and life because of the discomfort to dogs and cats, rabbits and frogs, which may be involved in the search for means of guarding them.

#### EXPLORATION.

An immense extension has been effected in our knowledge of the distribution of plants and animals; and the elucidation of the causes which have brought about that distribution has been greatly advanced. The establishment of meteorological observations by all civilized nations, has furnished a solid foundation to climatology; while a growing sense of the importance of the influence of the "struggle for existence" affords a wholesome check to the tendency to overrate the influence of climate on distribution. Expeditions, such as that of the *Challenger*, equipped, not for geographical exploration and discovery, but for the purpose of throwing light on problems of physical and biological science, have been sent out by our own and other Governments, and have obtained stores of information of the greatest value. For the first time, we are in possession of something like precise knowledge of the physical features of the deep seas, and of the living population of the floor of the ocean. The careful and exhaustive study of the phenomena presented by the accumulations of snow and ice, in polar and mountainous regions, which has taken place in our time, has not only revealed to the geologist an agent of denudation and transport, which has slowly and quietly produced effects, formerly confidently referred to diluvial catastrophes, but it has suggested new methods of accounting for various puzzling facts of distribution.

#### PALÆONTOLOGY.

Palæontology, which treats of the extinct forms of life and their succession and distribution upon our globe, a branch of science which could hardly be said to exist a century ago, has undergone a wonderful development in our epoch. In some groups of animals and plants the extinct representatives, already known, are more numerous and important than the living. There can be no doubt that the existing Fauna and Flora is but the last term of a long series of equally numerous contemporary species, which have succeeded one another, by the slow and gradual substitution of species for species, in the vast interval of time which has elapsed between the deposition of the earliest fossiliferous strata and the present day. There is no reasonable ground for believing that the oldest remains yet obtained carry us even near the beginnings of life. The impressive warnings of Lyell against hasty speculations, based upon negative evidence, have been fully justified; time

after time, highly organized types have been discovered in formations of an age in which the existence of such forms of life had been confidently declared to be impossible. The western territories of the United States alone have yielded a world of extinct animal forms, undreamed of fifty years ago. And wherever sufficiently numerous series of the remains of any given group, which has endured for a long space of time, are carefully examined, their morphological relations are never in discordance with the requirements of the doctrine of evolution. and often afford convincing evidence of it. At the same time, it has been shown that certain forms persist with very little change, from the oldest to the newest fossiliferous formations; and thus show that progressive development is a contingent, and not a necessary result, of the nature of living matter.

#### GEOLOGY.

Geology is, as it were, the biology of our planet as a whole. In so far as it comprises the surface configuration and the inner structure of the earth, it answers to morphology; in so far as it studies changes of condition and their causes, it corresponds with physiology; in so far as it deals with the causes which have effected the progress of the earth from its earliest to its present state, it forms part of the general doctrine of evolution. An interesting contrast between the geology of the present day and that of half a century ago is presented by the complete emancipation of the modern geologist from the controlling and perverting influence of theology, all-powerful at the earlier date. As the geologist of my young days wrote, he had one eye upon fact and the other on Genesis; at present he wisely keeps both eyes on fact and ignores the pentateuchal mythology altogether. The publication of the "Principles of Geology" brought upon its illustrious author a period of social ostracism; the instruction given to our children is based upon those principles. Whewell had the courage to attack Lyell's fundamental assumption (which surely is a dictate of common sense) that we ought to exhaust known causes, before seeking for the explanation of geological phenomena in causes of which we have no experience. But geology has advanced to its present state by working from Lyell's \* axiom; and to this day the record of the stratified rocks affords no proof that the intensity or the rapidity of the causes of change has ever varied between wider limits than those between which the operations of nature have taken place in the youngest geological epochs.

An incalculable benefit has accrued to geological science from the accurate and detailed surveys which have now been executed by skilled geologists employed by the Governments of all parts of the civilized

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\* Perhaps I ought rather to say Buffon's axiom. For that great naturalist and writer embodied the principles of sound geology in a pithy phrase of the *Théorie de la Terre*: "Pour juger de ce qui est arrivé, et même de ce qui arrivera, nous n'avons qu'à examiner ce qui arrive."

world. In geology the study of large maps is as important as it is said to be in politics; and sections, on a true scale, are even more important, in so far as they are essential to the apprehension of the extraordinary insignificance of geological perturbations in relation to the whole mass of our planet. It should never be forgotten that what we call "catastrophes" are, in relation to the earth, changes, the equivalents of which would be well represented by the development of a few pimples, or the scratch of a pin, on a man's head. Vast regions of the earth's surface remain geologically unknown; but the area already fairly explored is many times greater than it was in 1837, and in many parts of Europe and the United States the structure of the superficial crust of the earth has been investigated with great minuteness.

The parallel between Biology and Geology which I have drawn is further illustrated by the modern growth of that branch of the science known as Petrology, which answers to Histology, and has made the microscope as essential an instrument to the geological as to the biological investigator.

The evidence of the importance of causes now in operation has been wonderfully enlarged by the study of glacial phenomena, by that of earthquakes and volcanoes, and by that of the efficacy of heat and cold, wind, rain, and rivers as agents of denudation and transport. On the other hand, the exploration of coral reefs and of the deposits now taking place at the bottom of the great oceans has proved that in animal and plant life, we have agents of reconstruction of a potency hitherto unsuspected.

There is no study better fitted than that of geology to impress upon men of general culture that conviction of the unbroken sequence of the order of natural phenomena throughout the duration of the universe, which is the great, and perhaps the most important, effect of the increase of natural knowledge.

# RECORD OF SCIENCE FOR 1886.

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## ASTRONOMY, FOR 1886.

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By WILLIAM C. WINLOCK,

*Assistant Astronomer, United States Naval Observatory.*

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In preparing the review of Astronomy for 1886, the method and arrangement adopted by Professor Holden from 1879 to 1884 have been adhered to without essential modification. The record is intended primarily to serve as a series of notes for those who have not access to a large astronomical library, but it is hoped that the bibliography will be found useful to the professional astronomer as a reference list of technical papers.

Much assistance has been derived from the reviews and abstracts in the *Bulletin Astronomique*, the *Observatory*, *Nature*, the *Athenæum*, and other periodicals, and the writer is indebted to the directors of many observatories for the communication of information not otherwise available.

A subject-index to the review has been effected by inserting the necessary page-references in the bibliography.

### DISTRIBUTION OF STARS.

*Distribution of the stars in Schönfeld's Durchmusterung.*—The completion of the *Durchmusterung* to  $-23^{\circ}$  of declination by Argelander's successor, Dr. Schönfeld, has given Professor Seeliger the opportunity of extending his counts of stars to a considerable portion of the southern hemisphere. Professor Seeliger's paper "Über die Vertheilung der Sterne auf der südlichen Halbkugel nach Schönfeld's 'Durchmusterung,'" has been published in the *Proceedings of the Bavarian Academy of Sciences*, and résumés may be found in the *Bulletin astronomique* (3:593-6), the *Observatory* (9:399), and *Nature* (34:627). An abstract of Professor Seeliger's previous work was given in the "Account of the Progress in Astronomy" for 1884, and his present discussion has been carried out on a plan similar to that there described.



The stars are divided into eight classes, one more than previously used, as Schönfeld has included stars of the tenth magnitude, whereas Argelander stopped at 9.5.

Schönfeld's zones begin at  $-2^{\circ}$ , but the "counts" may be carried up to the equator by utilizing Argelander's work; the slight difference in limiting magnitude will not affect materially the result. The stars embraced in each degree of declination have been divided into groups of twenty minutes in right ascension, though only the sums for each forty minutes have been published.

The number of stars in each of the eight classes is as follows:

Classes.	Magnitudes.	A. Number of stars $-2^{\circ}$ to $-23^{\circ}$ .	B. Number of stars $0^{\circ}$ to $-23^{\circ}$ .
I .....	1 - 6.5	1,265	1,369
II .....	6.6-7.0	1,276	1,347
III .....	7.1-7.5	1,828	1,952
IV .....	7.6-8.0	3,516	3,800
V .....	8.1-8.5	7,601	8,313
VI .....	8.6-9.0	18,633	20,509
VII .....	9.1-9.5	55,565	61,540
VIII .....	9.6-10.0	43,896	43,896
Total .....		133,580	142,726

The numbers in column A comprise Schönfeld's stars only; column B includes Argelander's stars, from  $0^{\circ}$  to  $-2^{\circ}$ , for the first seven classes: to complete Class VIII about 3,600 should be added. The number of stars thus counted in the "Southern Durchmusterung" proper is, therefore, 133,580, and adding to this 79 objects which are classed as nebulae or variables, there results the grand total, 133,659.

In order to investigate the influence of the Milky Way on the distribution of these stars, Professor Seeliger proceeds, as in his former paper, to form the "gradient," which expresses for each class the rapidity of increase in the number of stars as we approach the Milky Way. Comparing the values of the gradient with these found for Argelander's Durchmusterung, it is seen that, as far as Schönfeld's work can be considered typical of the southern hemisphere as a whole (it must be remembered, however, that it only embraces one-third thereof) the influence of the Milky Way on stellar distribution, at least for stars down to the eighth magnitude, appears to be less marked for the southern than for the northern hemisphere. But it may well be that, especially in the higher classes of stars, local and accidental irregularities are the cause of this apparent difference. With regard to the question as to which hemisphere is the richer in stars, it appears that there is no decided difference shown by the two surveys under consideration. When Argelander's numbers are corrected so as to be comparable with Schönfeld's, taking stars down to the ninth magnitude, inclu-

sive, the totals are, for the former, 34,324, and for the latter, 34,119, a difference which may reasonably be attributed to accidental circumstances.

The whole discussion of the distribution of the stars will no doubt be much facilitated by the application of photography.

A writer in *L'Astronomie* has concluded that the total number of stars in "our nebula"—on the assumption that the combined light of the stars is equal to one-tenth that of the full moon—must be sixty-six thousand million.

#### NEBULÆ AND STAR CLUSTERS.

*New nebulae.*—Two lists, embracing 476 new nebulae discovered with the 26-inch equatorial of the Leander McCormick Observatory, have been published in the *Astronomical Journal* (7: 9, 57) by Professor Stone. The observers were Professor Stone himself, Mr. Leavenworth, and Mr. Muller. In the earlier observations Herschel's abbreviations were used to designate brightness and size. Afterwards numerical magnitudes were employed to indicate brightness, assuming that the faintest nebula visible in the 26-inch refractor with power 167, is 16.3, that being the theoretical limit for stars. The magnitudes given refer to the nucleus, or, in case there is no nucleus, to the brightest part. Still later the custom was instituted of estimating the diameters of the nebulae in fractions of the diameter of the field, and from these deducing their dimensions in minutes of arc.

Dr. Swift has published (*Astron. Nachr.*, 115: 153, 257; 116: 33) catalogues 3, 4, and 5 of nebulae discovered at the Warner Observatory. He states in the report of the observatory that 540 nebulae have been discovered up to January 1, 1887. Mr. Muller has found that fifteen of "Catalogue No. 5" have already been announced by other observers. (*Sid. Mess.*, 6: 83.)

*The Pleiades.*—M. Rayet, in order to test the penetrating power of the 14-inch Bordeaux equatorial, has made a revision of Wolf's chart of the Pleiades, and has determined accurately the positions of 143 stars, most of them of the fourteenth or fifteenth magnitude, not given by Wolf.

The Henry brothers have also compared their photographs of the Pleiades with Wolf's chart, and have been able to detect 1,421 stars where Wolf shows but 625, the telescopes used being of nearly the same aperture. In order to avoid errors which might arise from impurities in the photographic plate, three exposures, of an hour each, were made, and the plate was shifted between exposures, so that three images of each star are obtained, forming an equilateral triangle. Stars as faint as the sixteenth magnitude are depicted. All the stars of Wolf's chart are found upon the photograph except ten, and these the Messrs. Henry have been unable to find in the sky. A number of faint companions have been detected close to several of the brightest stars of the group,

and in several cases where M. Wolf has observed a faint companion to a bright star, the photograph has shown that the magnitude of the former was underestimated. One of the advantages of photography seems to be that it brings out faint objects which are lost to the eye, on account of their proximity to bright stars. Besides the nebula discovered about Maia, a nebulous streak has been seen near Electra, and details of the Merope nebula have been made out, which had not been recognized before, except by Common.

Dr. Weiss has expressed a strong suspicion that all of the region to the north and west of Aleyone is a vast nebula, only the brightest portions of which are shown by our best telescopes. He recalls a statement by Schmidt in 1863, that a small planet seemed to lose a part of its light in traversing the region between Aleyone and Electra.

Dr. Kammermann has been able to see the new Maia nebula with the 10-inch refractor of the Geneva Observatory by masking the bright star, and by using a special eye-piece provided with diaphragms, and a plate of uranium glass, to increase the intensity of the chemical rays.

A paper by Dr. Elkin upon "A comparison of the places of the Pleiades as determined by the Königsberg and Yale College heliometers" was read at the Buffalo meeting of the American Association. Provisional results show unquestioned change of position with reference to  $\eta$  Tauri since 1840. Most of the brighter stars of the group, as shown by Newcomb in his "Standard Stars," go with  $\eta$  Tauri, but among the smaller stars there are departures from this community of proper motion. Professor Pickering has pointed out that the agreement of the spectra of certain of these stars strongly confirms the probability of their physical connection.

#### ASTRONOMICAL CONSTANTS.

*Læwy's method of determining the elements of refraction.*—M. Læwy has elaborated his method of determining the elements of refraction by means of a reflecting prism placed in front of the object-glass of an equatorial, and has submitted the problem to a careful mathematical analysis in several papers communicated to the French Academy. The full titles of these important papers are given in our "bibliography." Dr. Gill speaks very highly of the plan, and has suggested some modifications of the details which he thinks would increase the ease and accuracy of observations.

*Oppolzer's astronomical refraction.*—The late Dr. von Oppolzer published in the Transactions of the Imperial Academy of Sciences, of Vienna, a paper containing a theoretical discussion of the problem of astronomical refraction followed by numerical tables intended to facilitate the practical application of the results at which he arrived. When the approximations are carried far enough, the method seems capable of giving results of great accuracy, even for large zenith distances.

*A correction for gravity in the use of refraction tables.*—Prof. Cleve-

land Abbe has directed attention to a neglected correction in the use of refraction tables, which appears as a function of the latitude. Thirty inches of mercury in the barometer at the equator indicate a less density of the atmosphere than 30 inches at the poles, consequently the barometer readings should be corrected for differences of latitude. This is accomplished by simply adding to the formula one more factor for gravity. Professor Abbe shows that the difference of latitude between Pulkowa and Washington makes a difference of  $0''.1$  in the refraction at  $45^\circ$  zenith distance, and increases with the zenith distance. We have here a partial explanation, at least, of systematic differences in declination shown by different catalogues.

*Correction for differential refraction in declination.*—Professor McNeill, of Princeton, has devised (Astron. Nachr., 114:385) a method of correcting micrometer observations for refraction, applicable to the diagonal-square micrometer, the ring micrometer, and others of the same class. The correction to the observed difference of declination is not determined by a special separate computation, but the true difference is directly determined, the corrections being applied to the logarithms in the course of the computation. Tables are given which will be found very useful to observers.

In a "Zusatz" to this communication, Dr. Krueger gives a résumé of differential refraction formulæ for ring and filar micrometers.

M. Radan suggests (Bull. astron., 3:373) that Professor McNeill's principal table may be replaced by a simple graphical table which will give at a glance the correction sought.

*The diurnal nutation of the earth's axis.*—M. Folie, about three years ago, submitted to the Paris Academy a theory of the diurnal nutation of the earth's axis, based upon the assumption that the earth has a fluid nucleus; and he has recently given (Compt. Rend., Dec. 13, 1886) some practical illustrations of his formulæ. These formulæ contain two constants to be determined by observation: the constant of diurnal nutation itself, and the longitude, referred to an initial meridian. Very accordant results are obtained from the rather meager observational material available, the value of the diurnal constant being about  $0''.2$ . The new correction applied to a series of observations of Polaris made at Pulkowa, smooths out the discordant observations in a most surprising manner. Further investigation of this subject seems highly desirable.

An abstract of the paper read by Prof. J. C. Adams at the Philadelphia meeting of the American Association, September 11, 1884, "On the general values of the obliquity of the ecliptic, and of the precession and inclination of the equator to the invariable plane, taking into account terms of the second order," has appeared in the Observatory for April, 1886, vol. 9, p. 150-154.



## STAR CATALOGUES, ETC.

*Schönfeld's Southern Durchmusterung* (1855.0).—This catalogue contains the approximate positions of 133,659 stars between  $2^{\circ}$  and  $23^{\circ}$  of south declination—that is, all stars between those limits down to the tenth magnitude. It carries Argelander's "sweeps" as far south as the latitude of Bonn will permit, and is on essentially the same plan as the Northern *Durchmusterung*. In the details of the work, however, several improvements have been made: Instead of Argelander's little 3-inch glass, magnifying nine times, Dr. Schönfeld used a telescope by Schröder of  $6\frac{1}{4}$  inches aperture with a magnifying power of twenty-six, and with the field slightly illuminated. The width of the zones was  $1\frac{1}{2}^{\circ}$ , instead of  $2^{\circ}$ , the width of the older zones. This involved more hours of observation, but the accuracy of the work and the certainty of catching faint stars were increased, since the observer was not obliged to take in everything up to the limit of visibility. A further advantage which the Southern *Durchmusterung* possesses is that Dr. Schönfeld has himself made all of the observations and revisions, so that the work is more homogeneous than the Northern *Durchmusterung*. The observations were begun, after some preliminary experiments, on the 6th of June, 1876; by the 28th of March, 1881, the zones had all been observed for the second time. There are, including sixteen zones subsequently re-observed, 363,922 observations, all reduced to 1855.0. The revision, also by Dr. Schönfeld and with the same instrument, embraced 5,700 positions, and was finished between April, 1881, and March, 1884.

From the summary of the stars in each square degree it appears that the Southern *Durchmusterung* is richer in stars than the Northern, in the ratio of 1.21 to 1. The fainter stars (under the ninth magnitude) are much more thoroughly observed than before, the limit being the tenth magnitude instead of 9.5, that adopted by Argelander. The probable error of a single estimation of magnitude for stars of the 9.5 magnitude is only 0.11 magnitude, and for the seventh magnitude, 0.26 magnitude. The charts accompanying the catalogue contain an hour each in right ascension.

*The Argentine General Catalogue*.—The observations from which this catalogue was formed were made with the meridian circle of the Cordoba Observatory during the years 1872-'80. During these years the zone observations were the chief object of attention, and the catalogue contains the places of 32,448 stars whose positions were more elaborately determined during the progress of that great work, and constitutes an addition to our knowledge of southern stellar positions of perhaps not less importance than the Cordoba Zone Catalogue. The General Catalogue gives the positions for the epoch 1875.0 of most of the southern stars brighter than magnitude  $8\frac{1}{2}$ , the deficiencies in this respect being chiefly found north of the parallel of  $23^{\circ}$ , at which the zone begins. These omissions will be of comparatively small importance,

inasmuch as the Durchmusterung of Professor Schönfield comprises all the southern stars within this region, while accurate determinations of the brighter ones will have been made in the re-observation of Lalande's stars now nearly completed at the Paris Observatory.

*Pulkowa catalogue of 3,542 stars for 1855.0.*—Volume VIII of the Pulkowa Observations is to contain two catalogues of stars deduced from observations made with the meridian circle from 1840 to 1869. The first of these—the one that has just been published—contains, with the exception of the Pulkowa fundamental stars (observed with the transit instrument and vertical circle), all Bradley's stars between the north pole and  $15^{\circ}$  south declination, and also a comparatively small number of other stars down to the sixth magnitude, inclusive, given in the *Uranometria Nova* of Argelander, in the same part of the sky. A few fainter stars have also been taken into the catalogue. The whole work has been in the hands of Dr. Backlund. (Bull. astron., November, 1886.)

*Kam's catalogue of "Nachrichten" stars for 1855.0.*—"Dr. N. M. Kam of Schiedam has published in *Verhandelingen der Koninklijke Akademie van Wetenschappen*, Deel. 24 (Amsterdam), a star catalogue compiled from the places of stars determined by meridian observations, which have been extracted from volumes 1 to 66 of the *Astronomische Nachrichten*, and reduced to the epoch 1855.0. The positions of the stars contained in this catalogue were determined in connection with observations of planets and comets, and it was in compliance with Argelander's express desire that the work of collecting them and reducing the positions to a common epoch was commenced by Hoek, then director of the Utrecht Observatory. Dr. Kam, who was Hoek's assistant, continued the work after the death of the latter, and has at length been able to publish his results. The principal catalogue contains the completely determined places of 4,350 stars, and is followed by two subsidiary catalogues, the first giving the places of 236 stars, and the second those of 335 stars; all of the latter, however, are incomplete, *i. e.*, the place is given in one element only. The catalogues are followed by a comparison of the places of the stars contained in them with their places as given in the Bonn Durchmusterung, or, for stars south of  $-2^{\circ}$  declination, with other authorities. Notes on proper motions, corrigenda, etc., are appended, which are of considerable interest and value." (Nature, June 3, 1886.)

*Romberg's catalogue of "Nachrichten" stars (1855.0).*—Herr Romberg, of the Pulkowa Observatory, has compiled a catalogue of about 8,000 stars extracted from the *Astronomische Nachrichten*, volumes 67 to 112, and his work now appears as Publication XVIII of the *Astronomische Gesellschaft*. This is a continuation of a similar compilation (Pub. VIII, Astron. Gesellsch.), by Schjellerup, from the first sixty-six volumes of the *Nachrichten*, and is prepared on much the same plan. The stars have appeared in the *Nachrichten* as comparison stars for planets, comets, etc., and have been collected by Romberg and reduced to 1855.0.

Right ascensions are given to seconds of time, declinations to the nearest tenth of a minute of arc. The catalogue proper is followed by several useful pages of notes.

*Edinburgh catalogue.*—Prof. Piazzì Smyth has given in volume xv of the Edinburgh Astronomical Observations the results of observations made from 1833 to 1872 upon some 3,890 B. A. C. stars, reduced to the epochs 1830, 1870, 1880, and 1890. The catalogue begins with  $4^h 0^m$  of right ascension, the first four hours having appeared nine years ago as volume xiv. The notes contain information in regard to the proper motion, color, or duplicity of the stars.

*Second Armagh catalogue of 3,300 stars for 1875.0.*—After the completion of the observations of Bradley's stars, the results of which were embodied in the catalogue commonly known as the "Armagh Catalogue," Dr. Robinson formed the plan of re-observing a number of stars from Lalande's "Histoire céleste," occurring in Baily's catalogue. Observations were commenced in 1859 with the  $3\frac{3}{4}$ -inch mural circle and transit, but were stopped after 1860 in order to change the mural into a 7-inch transit circle. Work was resumed in 1863, and continued with more or less regularity till 1883. The right ascensions of this catalogue depend on the standard stars of the "Nautical Almanac;" the north polar distances upon observations of the nadir. Dr. Dreyer, who succeeded Dr. Robinson in 1882, found from 400 observations of 80 stars between  $30^\circ$  and  $100^\circ$  N. P. D., that the probable error of a single observation in right ascension was  $\pm 0^s.081$ , (the single errors having been multiplied by  $\cos \delta$ ); and in north polar distance  $\pm 0''.85$ . For systematic errors Armagh has been compared with Glasgow, and, indirectly through the latter, a comparison is obtained with Auwers' fundamental system. From this comparison it appears that the north polar distances are in fair agreement with Auwers' catalogue, while the right ascensions show considerable discordances.

*Reliability of the star-places of Auwers' Fundamental Catalogue.*—Mr. Chandler, having pointed out the possibility of error in the places of certain stars (Observatory 8:387), as given in the Berlin "Jahrbuch," Herr Auwers has been induced to publish (Astron. Nachr., 114:1-20) some valuable and interesting remarks on the reliability of the places of his Fundamental Catalogue (Pub. d. astron. Gesellsch., 14), from which those given in the Berlin "Jahrbuch" are derived. Herr Auwers explains the provisional character of the data on which some of his star-places depend, and repeats in a more definite manner what he has already said on the subject in Publication xiv. In fact the proper motions adopted for some of the stars are merely provisional, as has been pointed out in the introduction to the catalogue. The proper motions employed have been, as a rule, obtained from a comparison of Bradley's places with those of Greenwich, 1861, and in those cases in which Bradley has only one observation, or observed the star in one element only, the proper motion is given to one decimal place less than usual. The reader



is thus put on his guard, and knows that he should use the places of certain stars with circumspection. Herr Auwers thinks that it would be premature to attempt any correction of the catalogue-places before the completion of the general revision, which has been undertaken by the observers of the zones and by the Pulkowa astronomers. He, however, takes this opportunity of publishing the results of investigations he has made as to the mean errors of the different catalogues employed in the formation of the Fundamental Catalogue, viz, Pulkowa, 1845 and 1865; Greenwich, 1861 and 1872; Cambridge (U. S.), 1872; Leipzig, 1868; and Leiden, 1868, for the principal stars; and in addition to these, Pulkowa, 1871, for the supplementary stars.

The following are, in the mean (for declination  $-10^{\circ}$  to  $+90^{\circ}$ ), the mean errors, referred to the unit of weight, for the principal stars:

	P. 1845.	P. 1865.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R. A. ( $\varepsilon \cos \delta$ )..	0 <sup>s</sup> .040	0 <sup>s</sup> .033	0 <sup>s</sup> .038	0 <sup>s</sup> .032	0 <sup>s</sup> .031	-----	-----
Decl. ( $\varepsilon$ ) .....	0'''.51	0'''.61	0'''.55	0'''.52	0'''.86	0'''.46	0'''.58

And for the supplementary stars:

	P. 1845.	P. 1871.	G. 1861.	G. 1872.	C. 1872.	Lp. 1868.	L. 1868.
R. A. ( $\varepsilon \cos \delta$ ) .	0 <sup>s</sup> .043	0 <sup>s</sup> .057	0 <sup>s</sup> .053	0 <sup>s</sup> .034	0 <sup>s</sup> .035	-----	-----
Decl. ( $\varepsilon$ ) .....	-----	0'''.72	0'''.64	0'''.52	0'''.89	0'''.72	0'''.52

We have then, finally, for mean error of the right ascensions 0<sup>s</sup>.033 (for supplementary stars 0<sup>s</sup>.042), and for the declinations 0'''.59 (for supplementary stars 0'''.67). The somewhat considerable difference in the results for principal and for supplementary stars arises from the circumstance that Herr Auwers gave relatively too much weight to Pulkowa 1871, at least for the right ascensions. For the catalogue-places, the mean errors are 0<sup>s</sup>.009 and 0'''.14 in R. A. and Decl., respectively, for the principal stars, and 0<sup>s</sup>.026 and 0'''.19 for the supplementary stars; where the mean error in R. A. refers to the total number of stars between  $-10^{\circ}$  and  $+50^{\circ}$ . At the present time, in Herr Auwers' opinion, the probable error of the star-places is not greater than 0<sup>s</sup>.02 in R. A. (for moderate declinations), and 0'''.15 in Decl. (Observatory, 9:202, May, 1886.)

In response to a suggestion by Dr. Gill, a number of astronomers have expressed their willingness to co-operate in the systematic observation of stars which have been used in comet comparisons, faint stars whose occultations have been observed, zones of stars used for scale or screw values, or stars that have been used for geodetic purposes. Among the observatories ready for this work are, the Cape of Good Hope, Neuchâtel, Bruxelles, Cointe, Tashkent, and Cordoba.



Professor Holden, while at the Washburn Observatory, compiled a list of all published corrections to his star catalogues, inserting the errata in the bodies of the books themselves. The original sources from which the errata were copied are given in the fourth volume of the Publications of the observatory. The value of this list will be appreciated by all astronomers who have occasion to make use of star catalogues.

The catalogue of stars of the British Association has been advertised recently at 170 mark, or about \$43.

#### STELLAR PARALLAX.

Prof. A. Hall has given in Appendix II to the Washington Observations for 1883 the results of recent observations made with the 26-inch equatorial to determine the parallaxes of  $\alpha$  Lyrae, 61 Cygni, 40 ( $\sigma^2$ ) Eridani, and 6  $\beta$  Cygni. The results are as follows:

Date.	Star.	Parallax.	No. of observations.
February 23, 1883, to March 4, 1884..	40 ( $\sigma^2$ ) Eridani.	+ 0.223 $\pm$ 0.0202	30
July 31, 1883, to April 15, 1886 .....	6 B Cygni .....	- 0.021 $\pm$ 0.0077	54
May 24, 1880, to July 2, 1881 .....	$\alpha$ Lyrae .....	+ 0.134 $\pm$ 0.0055	128
October 24, 1880, to January 26, 1886.	61 Cygni .....	+ 0.270 $\pm$ 0.0101	101

Dr. W. Schur has published in the *Astronomische Nachrichten* (vol. 114, p. 161), a discussion of the parallax of the double star  $\psi^5$  Aurigæ from measures of position, angle, and distance made with 6-inch Strassburg refractor, in 1883-'85. The final value for the parallax of the fainter (ninth magnitude) star is + 0''.111  $\pm$  0''.034. "Herr Schur thinks that he is justified in asserting that the parallax of this star is at least 0''.1—a remarkable result, considering the fixity of the object."

40 ( $\sigma^2$ ) *Eridani*.—Mr. J. E. Gore, using Professor Hall's parallax, 0''.223, has obtained by means of elements which he has computed, the following figures:

Distance of 40 Eridani from the earth.....	924,955
Mean distance between the components, B C .....	26.86
Sum of masses B C }	
Sun's mass = 1 }	1.003

The unit of distance is the mean distance of the earth from the sun.

#### DOUBLE STARS.

Two recent papers on personal equation in double-star observations will be found of especial interest to those engaged in this class of work. The first paper forms the subject of a thesis by M. Bigourdan, of the Paris Observatory, submitted for the degree of doctor of physical

science. M. Bigourdan reviews the work of others in this field, gives a description of apparatus which he has devised for investigating the problem by means of artificial stars, and deduces his own personal equation from a large number of measures made with this apparatus. He finds that his personal equation is not affected by the position of the eyes with respect to the line joining the stars nor by the altitude; the brightness of the stars, on the other hand, does affect his measures.

The second paper referred to is by Mr. H. C. Wilson, formerly of the Cincinnati Observatory, and is published in the *Sidereal Messenger* (vol. 5, pp. 174, 211). Mr. Wilson gives an interesting sketch of the history of the subject, together with an investigation of his personal errors, obtained from observations made between 1882 and 1886, with the equatorial of the Cincinnati Observatory. He finds that his measures, both of position angle and of distance, are slightly influenced by the inclination of the head.

*Spectroscopic method of determining the distance of a double star.*—Mr. A. A. Rambaut, of the Dublin Observatory, in a paper communicated to the Royal Irish Academy on May 24, 1886, discusses at some length the possibility of determining the distance of a double star by measures of the relative velocities of the components in the line of sight. Dr. Huggins having demonstrated that it was practicable to measure the rate of approach or recession of a star, it was seen that it would be at least theoretically possible to determine the distance of a star by this method. Mr. Rambaut's critical examination of the conditions of the problem shows however that the method can have but little practical application.

*Orbits of double stars.*—The following table gives the "period of revolution" in years, and "semi-axis major," in seconds of arc, obtained for a number of binary stars in recent determinations of elements:

Star.	Period.	Semi-axis major.	Computer.	Published in—
	<i>Years.</i>	<i>"</i>		
OS 234 .....	63.45	0.339	Gore .....	Astron. Nachr., 115:111.
ζ Sagittarii .....	18.69	0.53	...do .....	Month. Not., 46:444.
τ Cygni .....	53.87	1.19	...do .....	Astron. Nachr., 115:215.
40 (α <sup>2</sup> ) Eridani .....	139.0	5.99	...do .....	Month. Not., 46:291.
β Delphini .....	30.91	0.517	...do .....	Proc. Roy. Irish Acad., 2 s., v. 4, No. 5.
γ Coronæ Australis .....	81.78	1.885	...do .....	Month. Not., 46:103.
γ Coronæ Australis .....	78.80	1.85	Wilson...	Sid. Mess., 5:251.
α Centauri .....	87.44	18.89	Powell...	Month. Not., 46:289, 336.

# VARIABLE, NEW, OR TEMPORARY STARS—COLORED STARS.

*Observations of variable stars in 1885.*—Professor Pickering prints in the twenty-first volume of the *Proceedings of the American Academy* his third annual report upon observations of variables, giving particu-

lars of nearly two hundred stars for 1885. The work has been done by co-operation. All who are willing to assist (a field-glass is sufficient instrumental equipment), are requested to send accounts of their work to the Harvard Observatory as soon as possible after the close of each year. Professor Pickering undertakes to make photometric observations of all comparison stars needed.

Mr. Espin, the special observer of the Liverpool Astronomical Society, has commenced the issue of a circular calling attention to various variable stars or stars suspected of variability.

Several interesting cases of variability have been discovered by Messrs. Chandler and Sawyer, of Cambridge. The most interesting case is a new variable of the Algol type discovered by Mr. Chandler in the constellation Cygnus (R. A.  $20^h 48^m$ ; Decl.  $+34^\circ 14'$ ). The range is from 7.1 magnitude to 7.8 magnitude, the whole variation taking place in about six hours. The only doubt is in regard to the interval during which the star remains at its normal magnitude. Mr. Chandler suspects that the whole duration between two successive periods of change will be found to be about one day, twelve hours.

*Gore's new variable near  $\chi^1$  Orionis (Nova Orionis).*—A mass of observations by skillful observers has accumulated, and will repay a thorough study.

It seems to be clearly established that this interesting star is a simple variable, and not one of the class to which the title "temporary" can properly be applied. M. Dunér, who observed the star at intervals from December, 1885, to April, 1886, found (Astron. Nachr., No. 2755), on renewing his observations at the end of October and the beginning of November, 1886, that it had unmistakably increased in brightness in the interval, and was continuing to do so. Herr Fr. Schwab and Mr. Espin confirm this conclusion, the former having observed the star early in last July, and having found it then fainter than the twelfth magnitude. Its period would appear to be not far from one year; Herr Schwab gives it as one or two weeks longer than one year, and as ranging in brightness from the sixth magnitude to  $12\frac{1}{2}$ , whilst M. Dunér assigns a period of 359.5 days. (Nature.)

According to Dr. Vogel and others who have examined its spectrum, it belongs to Type III a, resembling the spectrum of  $\alpha$  Orionis.

*The new star in the great nebula of Andromeda.*—Professor Seeliger has published (Astron. Nachr., No. 2710) an interesting paper containing an attempt to represent the observed variations of the light of the *Nova* in Andromeda by a formula expressing the rate of cooling of a hot sphere. Supposing that such a body has its temperature suddenly increased to an enormous extent by some shock, its brightness will of course be increased also. And assuming that the latter is proportional to the  $n$ th power of the temperature, and using Pogson's scale for transforming brightness into stellar magnitude, Professor Seeliger (making

some further more or less probable assumptions) deduces an expression for the magnitude of the cooling star at any time. In order to compare this formula with Herr Müller's photometric measures of the *Nova*, extending from 1885, September 2, to October 13, Professor Seeliger assumes that  $n=1$ , and that the epoch for which the time  $t=0$ , is 1885, August 27, 8<sup>h</sup> Berlin mean time. Using quite approximate values of the constants involved in his formula, it appears that there is a good general agreement (the mean discordance being 0.11 of a stellar magnitude) between the computed and observed values. The computed magnitude corresponding to the epoch for which  $t=0$ , is 7.73. The fair agreement shown by this comparison induces Professor Seeliger to think that the form of the expression which he has deduced is such as would accurately represent the observations, provided that it were possible to determine the necessary constants with sufficient precision. And as there is evidence to show that the nebula in Andromeda is, partly at least, composed of a vast number of faint stars, it appears, in Professor Seeliger's opinion, not unreasonable to suppose that a collision was the cause of the sudden development of heat and light which revealed itself to us as the appearance of a "new" star.

With reference to the point thus raised by Professor Seeliger, Herr Auwers points out (*Astron. Nachr.*, No. 2715) that the great similarity of the outburst in Andromeda in 1885 to the phenomenon observed by him in 1860 in the cluster 80 Messier in Scorpio is a strong confirmation of Professor Seeliger's views. The probability that two variable stars of such exceptional character should be projected, in one case on a close star-cluster, in the other case on an object which appears to be, in part at least, a close star-cluster, is so small that it is almost necessary to refer these outbursts to physical changes in the nebulae in which they respectively appeared. (*Observatory*, April, 1886.)

Dr. Mills (*Nature* 33 : 440) in criticising Professor Seeliger's collision hypothesis suggests that the blazing out of the *Nova* may be merely a physico-chemical consequence of cooling; and it has been pointed out by Mr. Castell-Evans (*Nature*, 33 : 486) that practically the same explanation was suggested in 1878 by Prof. R. Meldola in a paper published in the *Philosophical Magazine* for July of that year. Professor Meldola says: "It is conceivable that in certain cases the composition of a star's atmosphere may be such as to permit a considerable amount of cooling before any combination takes place among its constituents; under such circumstances a sudden catastrophe might mark the period of combination, and a star of feeble light would blaze forth suddenly, as occurred in 1866 to  $\tau$  Coronæ Borealis. In other cases, again, it is possible that the composition of a star's atmosphere may be of such a nature as to lead to a state of periodically unstable chemical equilibrium; that is to say, during a certain period combination may be going on with the accompanying evolution of heat, till at length dissociation



again begins to take place. In this manner the phenomena of many variable stars may perhaps be accounted for."

Dr. von Kövesligethy observing with a 7-inch Merz equatorial at the observatory of Baron Podmaniczky at Kis Kartal, in Hungary, announced the re-appearance of the *Nova* on September 26, 1886. From this date he found that it became more star-like, and up to the evening of October 2 both nucleus and new star were visible. From October 2 to October 17 the old nucleus was invisible. By October 23 the nucleus had assumed its normal state, but the new star was not seen. A number of telescopes were immediately turned upon the nebula, but in the main failed to detect the changes suspected. (*See Astron. Nachr.*, 2750-2752.) It is probable that the object seen was one of the very faint points of light known to exist near the nucleus of the nebula.

A very complete series of observations of *Nova Andromedæ* is given by Dr. Copeland, of the Dun Echt Observatory, in the Monthly Notices for December, 1886.

*Catalogue of colored stars.*—Mr. W. S. Franks has presented to the Royal Astronomical Society a catalogue (not printed, apparently) of 1,730 colored stars situated between the pole and  $-20^\circ$  of declination, and including all stars down to the 6.5 magnitude. The introduction to this catalogue, giving a tabular analysis of the colors recorded, is published in the Monthly Notices for April, 1886.

We should mention also a list of thirty-one prominent colored stars of the southern hemisphere published by Mr. A. S. Williams in the *Astronomical Register* for October.

Mr. Chambers stated at the meeting of the Royal Astronomical Society on March 12, 1886, that he was preparing a catalogue of red stars.

#### STELLAR PHOTOMETRY.

*Photometric observations at Harvard College Observatory.*—Professor Pickering, in his annual report, states that 59,800 separate photometric comparisons were made with the meridian photometer in 1886. The instrument has been found to give entire satisfaction both in the accuracy and the rapidity of its work. Various tests have been applied to detect the presence of systematic errors, but so far with negative results. "A comparison of the seven hundred stars common to the observations of Wolff, Pritchard, and the Harvard Photometry, showed that our results differed on the average from Wolff, after allowance for systematic differences, by 0.140 of a magnitude; from Pritchard by 0.145; while Wolff and Pritchard differed from each other by 0.192. A comparison of the fifty five stars proposed by Professor Pritchard as standards, and measured by him on several nights, showed that the average deviation from the Harvard Photometry was only 0.104. - - - A comparison between the results obtained at Pulkowa and Cambridge shows that the average deviation of a measurement of the difference in brightness be-

tween two stars observed at both places does not exceed one-tenth of a magnitude."

The principal work of the meridian photometer, the revision of the Durchmusterung magnitudes, is now approaching completion, nine-tenths of the observations having already been made. During 1887 the observing list will be extended to include stars in the first  $20^\circ$  of south declination.

Observations of the eclipses of Jupiter's satellites, comparison stars for variables, etc., are made with the photometer attached to the 15-inch equatorial.

*A comparison of photometric methods.*—Mr. S. C. Chandler, jr., presented at the Buffalo meeting of the American Association an important paper on "A comparative estimate of methods and results in stellar photometry," in which he reaches the conclusion (also reached by Dr. G. Müller, of Potsdam,—*Vrtljschr. d. astron. Gesellsch.*, 20: 261–267), that the photometers now in use give no advantage, in point of accuracy, over direct eye-estimates of differences in magnitude made according to Argelander's well known method. With regard to accidental errors, Mr. Chandler concludes that "eye-estimates" are nearly three times as accurate as photometric measures, and he also points out that several variables have been detected and their periods and light-curves well determined by careful eye-estimates, whose whole range of brightness is no greater than the range of error in photometric observations. Reference should be made to Mr. Chandler's paper in the *Astronomische Nachrichten*, vol. 115, p. 145, merely an abstract of his communication having been published in the *Proceedings of the American Association*. 4212. Pickering Assn.

*A proposed new catalogue of magnitudes of southern stars.*—Mr. E. F. Sawyer, of Cambridge, has been at work since 1882 upon a determination of the relative magnitude of the stars included between the equator and  $30^\circ$  of south declination, and not fainter than the seventh magnitude. The observations are made with an opera glass (magnifying two and a half times) put slightly out of focus. The number of stars comprised will approximate 3,500, and the average number of observations for each star will be about three and one-half. Mr. Sawyer finds from 593 stars, each observed twice, that the average difference between two independent determinations of a magnitude of a star is 0.112 of a magnitude, which corresponds to a probable error of a single observation of  $\pm 0.035$ . It is expected that the work will be completed and ready for publication within a year.

#### STELLAR SPECTRA.

*Photographic study of stellar spectra at Harvard College Observatory.*—Professor Pickering has announced in his annual report an extensive investigation in stellar spectra, by means of photography, undertaken

at the Harvard Observatory. Provision has been made by Mrs. Draper for meeting the expenses of this work, as a memorial to her husband, the late Dr. Henry Draper.

Three researches are now in progress.

The first includes a general survey of stellar spectra. Each spectrum is photographed with an exposure of not less than five minutes, and these photographs generally exhibit the spectra of all stars brighter than the sixth magnitude with sufficient distinctness for measurement. The greater portion of the sky north of  $-30^{\circ}$  has been surveyed in this work, which will be repeated during the coming year. One hundred and fifty-one plates have been measured and 5,431 spectra examined and classified. Of these 4,148 have been identified and the name and position of the corresponding star entered opposite each. The completed work will form a catalogue probably containing three or four thousand stars, each photographed on several plates.

The second research relates to a determination of the spectra of the fainter stars. Each photograph taken in the course of this research receives an exposure of one hour, so that the spectra of all the stars not fainter than the eighth or ninth magnitude, and included in a region ten degrees square, are represented upon the plate. On fifty-eight plates 2,416 spectra have been measured, and of these 2,359 have been identified.

In both of these investigations the 8-inch Bache telescope has been employed.

The third research relates to a more careful study of the spectra of the brightest stars. For this work Mrs. Draper has lent the 11-inch photographic lens employed by her husband. She has also furnished an admirable mounting for the instrument and a small observatory to contain it. Two prisms have been constructed to place in front of the object-glass, the large one having a clear aperture of 11 inches square and an angle of nearly  $15^{\circ}$ , the other being somewhat smaller. The preliminary results attained with this apparatus are highly promising.

A recent photograph of the region in Cygnus where four stars were known, exhibiting the interesting peculiarity of bright-line spectra, brought out four more spectra of the same kind. One of these is the comparatively bright star P Cygni, in which bright lines, apparently due to hydrogen, are distinctly visible. This phenomenon recalls the circumstances of the outburst of light in the star T Coronæ, especially when the former history of P Cygni is considered. According to Schönfeld, it first attracted attention as an apparently new star in 1600, and fluctuated greatly during the seventeenth century, finally becoming a star of the fifth magnitude, and so continuing to the present time. Another of the stars shown by the photograph to have bright lines is DM. +  $37^{\circ}$ , 3821, where the lines are unmistakably evident.

ASTRONOMICAL PHOTOGRAPHY.

The improvements in astronomical photography during the past two years, following the introduction of the modern dry plates, have attracted wide-spread attention, and the great merits of the new method scarcely call for any exaggeration in order to establish photography permanently as a means for astronomical research. We find Greenwich, Harvard, Paris, Cape of Good Hope, and Lick taking steps to make stellar photography a part of their routine work, and arrangements have been made by Admiral Mouchez for holding an international conference at Paris in April, 1887, for the purpose of elaborating a plan of co-operation in photographing the whole sky. It is hoped that ten or twelve observatories will be ready to co-operate and that all will be supplied with instruments of the same power, so that the work will form a homogeneous whole. It will require 11,000 plates of 4° each to cover the sky, and ten years will probably be necessary for the completion of the undertaking.

*Stellar photography at the Paris Observatory.*—An article in *Nature* (May 13, 1886), which gives a wood-cut of the apparatus used by the Messrs. Henry, gives also the following table of the time of exposure required (with the Monckhoven gelatino-bromide plates) to obtain stars of different degrees of brightness:

Magnitude.		Time of exposure.
1		0 <sup>s</sup> . 005
2		0. 013
3		0. 03
4		0. 08
5		0. 2
6	The limit of magnitude visible to naked eye	0. 5
7		1. 3
8		3
9		8
10	} Mean magnitude of the asteroids	20
11		50
12		2 <sup>m</sup> 0
13		5 0
14		13 0
15	} The smallest stars visible in large telescopes	1 <sup>h</sup> 23 0
16		

These figures represent a minimum. To secure good reproductions on paper the time of exposure would have to be increased threefold. A two hours' exposure gives stars much fainter than Herschel's *debilissima*.

The Henrys have successfully photographed the clusters in Hercules, Sobieski, Ophiuchus, and Perseus, and the major planets. They have obtained the trail of an eleventh-magnitude asteroid—a fine line among the stellar points. The new method seems well adapted, also, to the search for a trans-Neptunian planet.

The observatories at Algiers and Rio Janeiro are to be supplied with instruments similar to those at Paris, and an equatorial coudé of 0.6 meter (24 inches) aperture provided with a photographic objective is to be constructed for the Paris Observatory, to test the adaptability of this form of instrument for photographic work.



*Stellar photography at Harvard College Observatory.*—Professor Pickering's investigations, which were briefly referred to in last year's report, have been published in full in the *Memoirs of the American Academy* (vol. 11, pp. 179–226). His paper contains a sketch of the history of the subject, description of the apparatus, discussion of theoretical considerations, and some results obtained in the three departments of "star-charting, photographing star trails, and spectrum photography." His work on the photography of stellar spectra we have already alluded to in the present review.

In the report of the Harvard Observatory for 1886 it is stated that the investigation in stellar photography undertaken with the aid of the Bache fund is now nearly completed. The principal results obtained include photographs of the entire sky north of  $-30^\circ$ , on which all stars bright enough to leave trails without the aid of clock-work are depicted. One series of plates exhibits the effect of atmospheric absorption on nearly every night of observation for a year; and among the miscellaneous observations may be mentioned some experiments in the application of photography to transit instruments, which showed that the accidental errors did not reach one-half of those affecting eye-observations. Various photographs were taken of the nebula of Orion to show the relative brightness of different portions of this object. The nebulae in Andromeda, in Lyra, and in the Pleiades were also photographed. An attempt was made to photograph a satellite of Jupiter while undergoing eclipse, and thus to determine the time of this phenomenon.

*Astronomical photography at the Lick Observatory.*—In a very interesting article upon astronomical photography, published in the *Overland Monthly* for November, 1886, Professor Holden thus summarizes the facilities of the California observatory for investigations in this field: "We expect to have a photographic objective as large as 36 inches in aperture, if the glass for this can be obtained. This will be mounted in the most perfect manner, and we shall employ the 12-inch Clark telescope, now at the observatory, as a pointing telescope for the large objective. The 12-inch telescope will be mounted alongside the other. An electrically-controlled driving clock will keep the two telescopes accurately directed during the exposure. Our objective will collect nine times the light of any other photographic telescope now made. - - - The focal length of the combination will be about 580 inches, and 1" on the plate will therefore be 0.002 inch. This is a quantity whose  $\frac{1}{100}$  part can easily be measured. A single exposure will give us a map of the sky comprising four square degrees on a plate 24 by 24 inches. - - - The sun's image unmagnified will be 6 inches in diameter; a large sun-spot will be the size of one's finger-nail. - - - The photographs of the moon in the focus of the Lick equatorial will be 6 inches in diameter, and will probably stand an enlargement of twelve times, so as to be 6 feet finally."

*Stellar photography at Cordoba.*—Dr. Gould, in a paper read at the Buffalo meeting of the American Association, has described the photographs taken at Cordoba from 1872 to 1882. About seventy southern clusters and more than a hundred double stars were repeatedly photographed. Some sixteen plates of the Pleiades and five of Præsepe were obtained; the total number of photographs being somewhat less than thirteen hundred. Dr. Gould lays great stress on the necessity of promptly converting the photographs into a permanent numerical record: and considerable uneasiness is aroused by the discovery that the collodion or gelatine films are readily detached from the plates. Some progress has already been made in the reductions, under Dr. Gould's immediate supervision at Cambridge.

*Pritchard's "Researches in stellar photography."*—In a paper with the foregoing title, read at the meeting of the Royal Society, May 27, 1886, Professor Pritchard gives an account of a number of photographs of the Pleiades which he has submitted to a critical examination, with the following objects in view:

(1) To ascertain, by means of definite and accurate measurement, the relation between the diameter of a star-disk impressed on a photographic plate with a given exposure, and its photometric magnitude; a simple formula seems to connect the two. (2) To ascertain whether the photographic plate remains an absolutely accurate picture of the actual relative positions of the stars in the sky itself, and, moreover, whether these are measurable with that extreme degree of precision which is attainable with the best instrumental means. The satisfactory accordances of measures of different plates have afforded a sufficient answer to this inquiry. (3) The third subject of investigation was the relation between the areas of the impressed star-disks and the time of exposure of the plates. As far as at present appears, these areas vary as the square root of the time, though the investigation is not to be regarded as complete. Bond, in 1858, considered that the areas varied directly as the time.

In the course of his work Professor Pritchard noticed what appeared to be a distortion of the photographic film on a small portion of the plate, and he detected a somewhat similar distortion upon one of eight plates of 61 Cygni and neighboring stars. He has hopes that in the course of a year the parallax of certain stars will be re-determined by photography, even to a greater degree of accuracy than has hitherto been achieved by direct instrumental application.

Professor Harkness has suggested that great increase in the accuracy of transit observations of the sun would be gained by inserting a sensitive photographic plate just behind the wire system of the instrument, and making an instantaneous exposure at the time of the sun's transit. This would avoid the disturbance of adjustments of the instrument arising from the exposure to the sun for several minutes, which is necessary in the present mode of observing. Stars would be observed and

the instrumental constants determined by using the eye-piece in the usual way.

#### COMETS.

Professor Bredichin in continuing his researches upon the mathematical theory of comets has re-determined the repulsive forces which produce the tails of different types. Making use of some forty comets in his discussion, he has found for tails of type I, a mean value,  $1-\mu=14$ ; but the comet of 1811, by far the most favorable for the determination of the repulsive force of this type, gave 17.5, and this represents quite well the tails of other comets. In this type the initial velocity  $g$  varies from 0.1 to 0.34, the mean being 0.23 (0.1=1.9 miles per second, about). In type II the forces vary from 0.5 to 2.2, and the initial velocities from 0.03 to 0.07, mean 0.05. For the axis of the tail  $1-\mu=1.1$ . In type III the repulsive forces lie between 0.1 and 0.3, and the velocities between 0.01 and 0.02.

Dr. Holetschek's investigation upon the conditions of visibility of a comet have been followed up by Dr. W. Meyer, who finds that if the great comets of 1843, 1880, and 1882 had reached perihelion in May they would have escaped unobserved. The orbit of the comet seen during the total eclipse of May 16, 1882, must have been very much like that of the comet which appeared four months later (1882 II); it seems, indeed, that the observed position can be represented to half a degree by the elements of the September comet, merely changing the time of perihelion of the latter and fixing it for the 17th of May. The ephemeris computed by Dr. Meyer with these elements shows very plainly why the Sohag comet could not be found after the eclipse, or had not been detected before; it was too faint when in a position favorable for observation. The comet is probably one of a regular stream of comets with small perihelion distance, such as 1843 I, 1880 I, 1882 II. If the orbits of the comets of 1843 and 1880 were sufficiently alike in other respects, the failure in repeated returns would be no objection to their identity, for if the returns have taken place in the month of May, the comet must have been invisible. A revolution in thirty-seven years is hardly to be reconciled, however, with the observations of 1843, and for the great comet of 1882 Frisby has found a period of seven hundred and ninety-four years.

Mr. Monck, in the Observatory for August and September, brings out some interesting statistics in support of his view that there exists a sort of "companionship" among comets—that is, cases in which the elements show a striking similarity; but it is improbable that the bodies are identical. Several of the comets of short period exhibit a family likeness which can hardly be attributed to their capture by Jupiter unless they previously formed members of a system. The question derives further interest from its bearing upon meteoric showers, for, if a family of comets can be supposed to be accompanied by a



family of meteors, a shower from nearly the same point might continue for a considerable time, giving rise to stationary radiants to which Mr. Denning has called attention.

It may not be out of place here to point out the value of physical observations of cometary phenomena—accurate observations of jets, tails, brightness, etc.—which may furnish data for testing any theories of their origin and constitution that may be put forward.

*Encke's comet.*—The progress of investigations upon Encke's comet may be briefly stated thus: The comet which has now been observed at twenty-four apparitions since its first discovery in 1786 “was shown by Encke to be subject to a remarkable decrease in the length of its period, a decrease which could not be accounted for by the attractive force of the sun and planets. Encke surmised that this was produced by the effects of a resisting medium. His calculations, which extended up to 1848, were continued by von Asten, who in a great measure confirmed Encke's conclusions, but found the curious anomaly that between the apparitions of 1865 and 1871, the acceleration of the mean motion which had been exhibited until the former of these years ceased to appear. Since the death of von Asten the work has been continued by Dr. Backlund, who has succeeded in showing that the apparent anomaly in question was due to an error in the formulæ of perturbations employed, and vanished when this was corrected. He was led however to the remarkable and interesting result that the acceleration of the mean motion of the comet is subject to a progressive diminution, and amounted between 1871 and 1885 to scarcely one-half of what it was between 1819 and 1865.” It was reduced from  $0''.104$  to  $0''.062$ . It seems very probable that about the year 1868 the acceleration underwent a change, due no doubt to some unknown modification in the physical condition of the comet.

Dr. Backlund has recently resumed his labors, which were interrupted by illness, and the first memoir, relating to the return in 1885, has just been printed; the second, treating of the comet's motion since 1865, will soon be presented to the St. Petersburg Academy of Sciences; while the third, which is in preparation, will comprise the period 1819–1868. For these researches the author has been awarded the Lalande prize of the Paris Academy.

*Comet Tempel-Swift.*—Bossert has given in the *Bulletin astronomique* an elaborate discussion of the orbit of the comet discovered by Tempel in 1869, but not recognized as periodic till its rediscovery by Swift in 1880. The period is about five and one-half years, but the comet escaped notice in 1875 and again in 1886.

*Comet 1873 VII.*—M. Schulhof has published (*Bull. astron.*, 3: 125 *et seq.*) a discussion of the orbit of this comet, and has gone into the question of its possible identity with 1818 I and 1457 I (the observations of which by Toscanelli have recently been discussed by Professor Celoria).



His conclusion, expressed with some reserve, is that 1873 VII and 1818 I are distinct bodies, with a short period of revolution but having a common origin. *Comet* 1457 I is probably identical with 1873 VII, but it is also possible that the two comets 1873 VII and 1818 I are fragments of 1457 I.

*Comet* 1877 VI.—Dr. Larssén, of Upsala, has completed the definitive determination of parabolic elements of the comet discovered by Coggia at Marseilles on September 14, 1877, and observed to December 10 of that year. The observations have been newly reduced and combined in five normal places, with a very satisfactory result. (*Astron. Nachr.* 116 : 23-26.)

*Comet* 1881 V.—The close agreement of the elements with those of the orbit of a comet discovered by Blanpain on the 28th of November, 1819, has led to a conjecture that the two comets are identical, although Blanpain's was computed to have a period of less than five years and Denning's of nearly nine, it being supposed that planetary perturbation had lengthened the period between the appearance of 1819 and that of 1881. It has been noticed both by Mr. Plummer and by Mr. Denning that the longitude of the ascending node of the 1881 comet corresponds almost exactly with that of the descending node of Biela's comet, which has not been seen as a comet (or rather double comet) since 1852, though it has been supposed to be connected with a very brilliant meteoric display seen on the 27th of November, 1872. The other elements of Denning's comet exhibit a remarkable agreement with those of Biela's comet; and the suggestion in question is that these comets are identical, or rather that Denning's is identical with the principal remaining portion of Biela's, which underwent violent perturbation through near approach to the earth in 1872, sufficient to lengthen its period and reverse the nodes (a necessary consequence of altering the inclination through zero). Colonel Tupman, whose calculations well confirm this theory, remarks "that on the 27th of November, 1872, it is probable that the comet was very near the earth and mixed up with the meteoric shower." The comet passed its perihelion on the 13th of September, 1881; the computed length of its period was 8.83 years, or about 3,225 days; and this was almost exactly the interval which had elapsed since the meteoric display of the 27th of November, 1872. If this theory be true, we can not expect another similarly brilliant display on that day until the year 1916, five periods of the comet's revolution in its orbit being very nearly equal to forty-four of the earth's. (*Athenæum.*)

*Comet* 1881 VIII.—Olsson finds a period of 612 years; that found by Oppenheim was 2,740 years, though Oppenheim remarks that 900 years would satisfy the observations almost as well.

*Comet* 1882 II.—The valuable series of observations of this comet made at the Cape of Good Hope, including the remarkable observation of the disappearance of the comet at the limb of the sun, has been published as vol. II, part 1, of the *Annals of the Cape Observatory*. Inter-

esting observations of the tail, accompanied by numerous sketches, are found in vol. I of the Publications of the McCormick Observatory, the observers being Messrs. Leavenworth and Jones.

*Comets of 1886.*—Nine comets passed perihelion in 1886; three of them visible to the naked eye. One was a well-known periodic comet returning at the appointed time, and two of the new-comers appear to be periodic, one of them identical possibly with De Vico's lost comet of 1844. Olbers's comet of 1815 was not detected, but as an uncertainty of some three years exists in the period of revolution, it may be picked up during the coming year. The Tempel-Swift comet due at perihelion on May 9 seems to have escaped notice on account of its excessive faintness. Of these nine comets, three belong to Barnard, three to Brooks, two were found by Finlay, and one by Fabry; two were discovered in 1885, one in 1887; leaving six discovered in 1886. Comet 1886 IX was picked up by three observers independently, on three successive mornings in October, showing what a careful watch is kept by comet-hunters. Warner prizes to the amount of \$800 were paid for the captures.

Comet 1886 I:

=Comet *d* 1885.

=Fabry's comet.

This comet, as noted in last year's report, was discovered on December 1, 1885, at Paris. From a faint little patch of nebulosity it grew steadily in size and brightness, and on March 29, 1886, Fabry described it as having a diffused nucleus about 15'' in diameter, comparable with a star of the seventh magnitude; a tail about 20' long and 4' broad, was thrust out in a position angle of 325°, while the nebulosity extended about 1'.5 beyond the head. It became rapidly more prominent, and on April 3 was visible without difficulty to the naked eye. On April 23 the head was as bright as a third-magnitude star, and the tail 4° long. The greatest length of the tail was probably about 9°, but the comet was not a very conspicuous object on account of its slight elevation above the horizon before sunrise, and also on account of the moon-light. It is said to have remained visible to the naked eye from the early part of April to beyond the middle of May. Observations were continued in the southern hemisphere until about the end of July.

The determination of the orbit presented some difficulties, and the elements from early observations were not entirely accordant. Dr. S. Oppenheim's elements (*Astron. Nachr.*, 2722), derived from observations extending to March 28, placed perihelion passage on April 5, 1886; the nearest point to the earth and greatest brilliancy (about four hundred and seventy-five times as bright as when discovered) were reached about May 1.

The spectrum was studied by Trépied, Perrotin, Rayet, Vogel, and others. The three bands common to comets and hydrocarbons were found—the central band, perhaps, somewhat intensified; and besides these bands there was also a continuous spectrum.

Dr. Müller, of Potsdam, has published in the *Nachrichten* (No. 2733)

a very interesting series of photometric observations of this comet and of the comet discovered by Barnard on December 3, 1885. The observations extended over the months of March and April, 1886; and both comets were increasing in brightness. Reducing the measures to a distance unity, the intrinsic brilliancy seems to have been tolerably constant; from which it may be concluded that the comets shone almost entirely with borrowed light. This conclusion is confirmed by Dr. Müller's spectroscopic observations, according to which the continuous spectrum predominates. Trépied, on the other hand, found that in Fabry's comet the proportion of reflected sunlight was small, gaseous elements predominating and the bands being much brighter than the continuous spectrum. Dr. Müller remarks that his observations show no effect of phase, and he suggests that this may be due to a variation in the inherent light of the comet as it approaches the sun and earth, or we may assume that the nucleus is made up of discrete particles by which the phase phenomena must to a great extent be modified.

#### Comet 1886 II:\*

=Comet *c* 1885.

=Barnard's comet.

A brief account of this comet was given last year, as it was discovered by Barnard on December 3, 1885, with a 6-inch Cooke equatorial. A small tail about 15' long was detected by Tempel as early as December 31. In April and May the comet developed into quite a fine object with stellar nucleus and fan-shaped tail, 2° or 3° in length. It was seen with the naked eye on May 7 and 12 by Mr. Barnard, at Nashville, and on May 31 and June 3 by Mr. Tebbutt, at Windsor, New South Wales. The last observation published was made on July 19, at Cordoba. A careful series of "extinction observations" is given by Dr. Holetschek in the *Nachrichten*, No. 2739. The spectroscope showed the three ordinary cometary bands, with faint, continuous spectrum of the nucleus.

The latest elements computed by Thraen from observations between December 5, 1885, and May 10, 1886, place perihelion passage on May 3, and give a slightly hyperbolic orbit (eccentricity=1.0004). Whether the curve really differs from a parabola can not be decided until all the observations, including those from southern observatories, can be taken into account. Morrison has obtained hyperbolic elements agreeing tolerably well with those of Thraen. Earlier elements showed a slight resemblance to comet 1785 II, but it is not probable that the comets are identical.

#### Comet 1886 III:

=Comet *b* 1886.

=Comet 1886.... (Brooks 2).

This was discovered by Mr. W. R. Brooks, at Phelps, New York, on April 30, 1886, or in civil reckoning on the morning of May 1; his second comet within four days. Mr. Brooks described it as having a small but bright and star-like head, and a conspicuous tail. On May 4 there was a tail 10' or 12' long; very bright near the origin. Engelhardt, on May 6, found the tail 40' long and nearly straight, while 8' from the nucleus there was a faint secondary tail bending towards the south. Pechüle, observing from May 3 to May 12, detected two



nuclei or condensations in the head. Barnard says it was a most singular-looking telescopic comet—"a perfect miniature of the naked-eye appearance of a great comet." It does not seem to have been observed beyond the last week of May, when its theoretical brightness was about half that at the time of discovery.

According to Wendell's elements the comet passed perihelion on May 5. Dr. Weiss called attention to the fact that at the ascending node the orbit approached quite near the orbit of the earth, so that when the earth passed the line of nodes, July 9, a meteoric shower visible in the southern hemisphere might result from particles following in the wake of the comet. We believe, however, that no unusual display was reported.

Comet 1886 IV:

= Comet *c* 1886.

= Comet 1886.... (Brooks 3).

Discovered on the evening of May 22, 1886, by W. R. Brooks, in the constellation Virgo, a large, nearly round, and feebly

luminous spot with a slight condensation occasionally visible. It was decreasing in brightness when detected, and passed out of sight early in July. Mr. Sherman, of the Yale Observatory, found the three cometary bands in its spectrum. Dr. S. Oppenheim has calculated an elliptic orbit with a period of about nine years. Dr. Hind makes the period very much shorter, not much more, in fact, than six and a quarter years, according to which the comet would return in the autumn of 1892. The perihelion passage took place on June 6 or 7. A new discussion of the orbit has been undertaken by Drs. Oppenheim and Bidschof, of Vienna.

Comet 1886 V:

= Comet *a* 1886.

= Comet 1886.... (Brooks 1).

Discovered by Brooks on the evening of April 27, the first comet found in 1886.

Until May 3 or 4 it was a round nebulous object 1' or 2' in diameter. An uncertain nucleus could occasionally be made out. On May 5 and 9 several bright points were seen in the nucleus, giving it a "granular" appearance. On May 18 the nucleus was of the eighth magnitude, and May 21 and 25, sixth to seventh magnitude with nearly circular coma 2' 20" in diameter. Dr. Krueger's elements show that the comet's nearest approach to the sun, 0.27 (the radius of the earth's orbit being unity), occurred on June 7.

Comet 1886 VI:

= Comet *d* 1886.

= Winnecke's comet.

Winnecke's periodic comet (five and two-thirds years) for which an ephemeris had been prepared by Dr. Lamp, was detected by Mr.

Finlay, of the Cape of Good Hope Observatory, on August 19. During its two or three weeks of visibility it was a faint, misty object, 1' or 2' in diameter, without tail, but with some central condensation. Perihelion was passed on August 19, about twelve days earlier than predicted by Dr. A. Palisa. An attempt was made at Paris to photograph the comet, but without success.

Comet 1886 VII:

= Comet *e* 1886.

= Finlay's comet.

Discovered by Mr. W. H. Finlay, of the Cape of Good Hope Observatory, on September 26, 1886, and reported as "faint, circular, about 1'



in diameter, with some central condensation, and no tail." The possible identity with "De Vico's lost comet," 1844 I, (for which Brünnow found a period of 5.5 years), immediately attracted attention, and elliptic elements have been calculated by Boss, Krueger, Oppenheim, and Holetschek. The computation of the orbit presents some difficulties, and it is impossible to settle the question of identity until all observations at this return have received a thorough discussion—if it can be settled then. The last set of elements obtained by Professor Boss (Astron. Journ., v. 3, p. 43) place perihelion passage on November 22, 1886, and give an approximate period of 6.675 years. With this period the comet, if undisturbed, should return to the sun in July, 1893, under conditions quite favorable for observation. It is still visible, nearly five months after discovery.

Comet 1886 VIII: A faint, telescopic comet was found by Barnard at Nashville on January 23, 1887 (the morning of January 24 in civil reckoning), which proved to have passed perihelion on November 25, 1886, and it therefore takes a place preceding the comet discovered by Barnard on October 4. As it was receding from the earth and the sun, it rapidly grew fainter. Perihelion distance obtained by Weiss was 1.4 times the mean distance of the earth from the sun.

Comet 1886 IX:  
 = Comet *f* 1886.  
 = Comet 1886 *f* (Barnard, October 4).  
 = Comet 1886.... (Barnard-Hartwig).

This comet was discovered by E. E. Barnard, at Nashville, Tenn., on October 4, 1886 (or morning of October 5). It was also discovered in-

dependently by Dr. E. Hartwig at the Bamberg Observatory on October 5, and by Dr. C. F. Pechüle, at Copenhagen, on October 6. It was an easy object in the telescope, and developed a tail early in October. By October 29 the nucleus was as bright as a star of the eighth magnitude, and the comet was visible to the naked eye as an ill-defined spot. Two distinct tails were detected about this time, and Barnard found a third on November 23. The comet was now easily seen with the naked eye, as conspicuous as a star of the fourth magnitude, with a slender train traceable for  $70^\circ$  or  $80^\circ$ . The tail seems to have reached a maximum length of about  $100^\circ$  during the first week of December, the theoretical brightness of the comet being then about twenty-five times that at discovery.

Riccò, of Palermo, found the spectrum composed of the three hydrocarbon bands, of which the middle one (green) was longest and brightest. The spectrum of the nucleus was continuous, but re-enforced at the bright bands.

Elements computed by Lieutenant Allen from observations reaching to December 10 show that perihelion was passed on December 16, 1886. No deviation from a parabola is indicated.

METEORS AND THE ZODIACAL LIGHT.

*The Biela meteors of November 27, 1885.*—Professor Newton has collected all the published data in regard to this great shower, and has submitted it to a thorough discussion in an article of nearly twenty pages of the American Journal of Science for June, 1886.

We quote merely his summary statement of conclusions :

- "1. The maximum of the shower was near 6<sup>h</sup> 15<sup>m</sup> Greenwich mean time.
- "2. Three hours after the maximum the number of meteors had diminished to one-tenth the maximum number, and it is not unreasonable to assume six hours as containing the principal part of the shower.
- "3. The total hourly number of meteors visible at one place in a very clear sky to some one or other of a very large group of observers may at maximum be regarded as 75,000.

"4. In the densest part of the meteor stream, where and when the earth encountered it, the space that corresponded to each meteoroid was equal to a cube whose edge was about 20 English miles.

"5. The dense part of the stream was not over 100,000 miles in thickness.

"6. The *zenithal attraction* of the Biela meteors was about one-tenth of the observed zenith distance of the radiant.

"7. The radiant was an area several degrees across.

"8. It is reasonable to suppose that the meteoroids, while in the upper part of the atmosphere, before the paths become luminous, change direction by a glancing due to irregularity of form. After the resistance has developed heat enough to melt or burn off projecting angles of the stones, and the tracks become luminous, the forms of the bodies become rounded in front and the paths described are straight lines.

"9. The meteoroids encountered by the earth on the 27th of November, in 1872 and in 1885, did not leave the immediate neighborhood of the Biela comet earlier than 1841-'45, and may be treated as having at that time orbits osculating that of the comet. The determination of the paths of these meteoroids through their five and seven last revolutions about the sun seems to be a problem capable of complete solution."

Professor Newton's presidential address at the Buffalo meeting of the American Association, on "Meteorites, meteors, and shooting stars," has been published in Science (8 : 169-76), and in Nature (34 : 532-36).

M. P. F. Denza reports that a careful watch maintained on the night of November 27, 1886, at seven observatories on the Italian peninsula, showed no repetition of the great shower of 1885. This would indicate that the stream is of small extent but very dense, and would tend to strengthen the hypothesis that it originated in the recent disintegration of Biela's comet.

Herr Förster finds for the radiant points of the great meteor showers of 1872 and 1885 :

1872	R. A. 23 <sup>o</sup> .3	Decl. + 43 <sup>o</sup> .3.
1885	23 <sup>o</sup> .5	+ 43 <sup>o</sup> .3.

A recent bulletin of the New England Meteorological Society gives a discussion, by Professor Newton, of a meteor seen on September 6, 1886, height, time and place of appearance and disappearance, etc. It is desired that observers should report the position of bright meteors, noting their paths among the stars, and trails, if any, with as much accuracy and detail as possible.

Mr. Denning publishes in the Monthly Notices for November some interesting results he has obtained from the study of a catalogue of more than 82,000 meteors from 3,035 radiants. Mr. Denning himself contributes to his catalogue no less than 7,000 meteors. He also, in another place, calls attention to the marked agreement between the orbit of Halley's comet and a pronounced meteor shower with radiant close to  $\gamma$  Aquarii. The maximum shower occurs about May 6. This radiant needs further observation.

*Relation of the zodiacal light to Jupiter.*—Dr. Geelmuyden, speaking of Professor Searle's researches upon the zodiacal light, says: "If the zodiacal matter has the same position among meteoric matter in general as comets of short period among comets, it is to be expected that the fundamental plane of the zodiacal light will have some relation to Jupiter as the principal motor in deflecting the orbits, and therefore in collecting the matter. Now it is worth remarking that the most northerly point of Jupiter's orbit has the heliocentric longitude  $188^\circ$ , or with  $60^\circ$  east elongation  $178^\circ$  geocentric longitude; and for matter in the same plane, but nearer the sun, the approximation to coincidence with  $160^\circ$  is still greater."

#### THE SUN.

*Motion of the solar system in space.*—Several attempts have lately been made to obtain the direction and rate of motion of the solar system in space. These results are discordant among themselves, and, as the investigators have remarked, are not entitled to very great weight, on account of the meagerness of the data available, but it may not be without interest to give the values obtained.

Herr Homann, from a discussion of the spectroscopic observations made at Greenwich, and from the observations of Huggin and Seabroke, finds:

	Velocity of translation, in miles per second.	Apex of solar motion.	
		R. A.	Decl.
Greenwich .....	$24.4 \pm 2.7$	$320^\circ.1$	$+41^\circ.2$
Huggins .....	$30.1 \pm 14.3$	$309.5$	$+69.7$
Seabroke .....	$15.2 \pm 9.8$	$278.8$	$+13.6$

There is only a rough sort of agreement, but all three unite in placing the apex considerably in advance, in right ascension, of the apex as found from the proper motions of stars by Struve, Airy, Dunkin, and others (the mean position generally assigned is, R. A.  $260^{\circ}$ ; Decl.  $+35^{\circ}$ ), while Struve found a velocity of translation of only about  $4\frac{1}{2}$  miles per second.

Herr Homann is inclined to think that the velocity of translation of the sun does not differ very much from the velocity of the earth in its orbit, that is,  $18\frac{1}{2}$  miles per second. Dr. von Kövesligethy in 1883 found from spectroscopic observations that the rate of motion of the solar system was 8.6 geographical miles per second. The spectroscopic observations were insufficient to determine the direction, and he assumed the apex in R. A.  $216^{\circ}.0$ , Decl.  $+35^{\circ}.1$ .

Dr. Ubaghs, of Liège, in making a preliminary examination of the aberration due to the motion of the solar system, pointed out by M. Folie, has obtained a result which would give a velocity of only about 180 feet per second.

*The velocity of light and the solar parallax.*—Professor Newcomb has published in vol. 2 of the “Astronomical papers prepared for the use of the American Ephemeris” the details of his researches on the velocity of light, made during the summer months of 1880, 1881, and 1882. The apparatus used, to which the name “photo-tachometer” has been given, is a modified form of Foucault’s revolving mirror. The result obtained for the velocity of light *in vacuo* is 299,860 kilometers, or 186,327 miles per second, with a probable error of 30 kilometers. Michelson found in 1879 a velocity of 299,910 kilometers, and repeating his work at Cleveland in 1882, he obtained 299,853. Accepting the value 299,860 as the true one, it becomes of interest to consider the value thereby deducible for the parallax and distance of the sun. The latest and probably the most accurate determination of the constant of aberration is that of Dr. Nyrén,  $20''.492$ . Combining this with the above velocity of light and Clarke’s value of the earth’s equatorial radius (6,378.2 kilometers), we obtain  $8''.794$  for the value of the solar parallax, almost exactly the same as that obtained from heliometer observations of Mars in 1877. The corresponding distance of the sun is 92,960,000 miles.

With regard to a possible difference between the velocities of rays of different colors, it is pointed out that the phenomena of variable stars seem to be conclusive against the hypothesis of any such difference. Were there a difference of one hour in the times of the blue and the red rays reaching us from Algol, this star would show a well-marked coloration in its phases of increase and decrease. No such effect, however, has been noticed. Recent researches by Professors Michelson and Morley have led to a similar result.

*Transits of Venus 1874 and 1882.*—The work of the United States Transit of Venus Commission is being rapidly carried to completion



under the immediate supervision of Prof. William Harkness. The reductions of observations made at the various stations for time, latitude and longitude are finished, the determination of longitudes having required a thorough examination of all the great chains of telegraphic longitude. A volume containing all of the observations for 1874—all of the 1874 work except the discussion of the photographs—is now in press.

Dr. Auwers reports, under date of January 11, 1886, that the reductions of the German heliometer measures are well advanced and that the printing has been begun; and M. Bouquet de la Grye announces for the French commission that the photographic plates, 1,019 in number, have been measured, and that the reductions are now half done, and will be finished about the end of 1887.

*Theory of sun-spots.*—Professor Young, in an article on “Recent advances in solar astronomy,” makes the following comments upon an important paper by M. Belopolsky, of the Moscow Observatory. published in the *Astronomische Nachrichten*, No. 2722:

“Some recent investigations upon the rotation of fluid masses, by Jukowsky, of Moscow, as applied to solar conditions by his colleague Belopolsky, seem to warrant a hope that the phenomena of surface-drift in longitude, and even the periodicity of the spots, may soon find a rational explanation as necessary results of the slow contraction of a non-homogeneous and mainly gaseous globe. The subject is difficult and obscure; but if it can be proved, as seems likely, that on mechanical principles, the time of rotation of the central portions of such a whirling mass must be shorter than that of the exterior, then there will be of necessity an interchange of matter between the inside and outside of the sphere, a slow *surface-drift* from equator toward the poles, a more rapid *internal* current along and near the axis from the poles toward the equator, a continual ‘boiling up’ of internal matter on each side of the equator, and, finally, just such an eastward drift near the equator as is actually observed. Moreover, the form of the mass, and the intensity of the drift and consequent ‘boiling-up’ from underneath might and probably would be subject to great periodic variations.

“This theory falls in well with the facts established by Spoerer respecting the motion of the sun-spot zones, and the general though slow poleward movement of sun-spots.”

*Sun-spot observations at Kalocsa.*—A summary (*Astron. Nachr.*, 116: 31) of sun-spot observations at Kalocsa, 1880–1885, shows the predominance of spots in the southern hemisphere of the sun over those in the northern hemisphere, particularly well marked, since the beginning of 1883. A similar result is shown in the Greenwich observations, and has also been pointed out by Dr. Spoerer; on the other hand, from 1880 to 1883 the northern hemisphere had the greater number of spots. It has been noticed, furthermore, that since 1880 the spots show a tendency towards the equatorial zones.

*Observation of sun-spot spectra.*—Professor Young mentions a somewhat curious observation of sun-spot spectra, which he has recently made. He finds that under high dispersion the spectrum of the darkest part of the spot is not continuous, but is made up of countless fine, dark lines, for the most part touching or slightly overlapping, but leaving here and there unoccupied intervals which look like (and may be) bright lines. “It seems to indicate that the principal absorption which darkens the center of the sun-spot is not such as would be caused by minute solid or liquid particles—by smoke or cloud, which would give a continuous spectrum; but it is a true gaseous absorption, producing a veritable dark-line spectrum, in which the lines are countless and contiguous.”

*Solar activity in 1886.*—According to Professor Tacchini’s observations (*Comptes Rendus*, 103:120; 104:216), it appears that there was a decided falling off in the number and size of sun-spots during the year 1886. In March, however, there was a considerable temporary increase; and on the 8th of May a magnificent group of spots was visible in the sun’s northern latitude. A well-marked minimum occurred in November, and rather peculiar “secondary minima” seem to have fallen in the months of February, May, and August. Prominences also showed a diminution in number and size compared with those seen in 1885, but the fluctuations were much fewer than in the case of the spots. A particularly remarkable eruption was observed on March 9 and 10.

Professor Tacchini places the last great minimum of spots in March, 1879, and the last maximum in February, 1884; if then the decrease in the number of spots during the latter part of 1886 corresponds to a new minimum, we shall have an interval from the last maximum of only 2.8 years, whereas the mean interval is seven years. So short an interval between maximum and minimum is very exceptional, for the shortest known since 1750 is 4.3 years; the longest is ten years.

*Total eclipse of the sun, August 28–29, 1886.*—A party consisting of Lockyer, Tacchini, Schuster, Maunder, Perry, and others, was sent out by the British Government to the island of Grenada, in the West Indies, to observe the total eclipse of August 28–29, 1886. A full review of the results of the expedition can not be given until the detailed report is ready. Preliminary accounts show that only one division of the party, that with Mr. Lockyer at Green Island, failed entirely on account of clouds, though the observations at some of the other stations were more or less interfered with. Photometric observations and photographs of the corona and of its spectrum were obtained, and also good spectra of the prominences, showing the bright lines of highly incandescent vapors. In this respect the result resembles that obtained in the two previous eclipses, though it was thought possible that this year, being one when sun-spots were tending to a minimum, would be marked by the more continuous spectrum that bespeaks lower temperature.

Prof. W. H. Pickering, of Boston, observing from Fort Green, obtained a number of photographs and some interesting photometric observations. He also organized a series of observations of the shadow bands.

Observations of the partial phase were made at the Azores, Martinique, Port au Prince, and at several points along the eastern coast of the United States. No parties were sent out by the United States Government.

*Photography of the solar corona.*—Dr. Huggins's method of photographing the corona in full sunshine seems to have failed when submitted to a crucial test in the eclipse of last August. In a letter to Science, dated September 11, 1886, Dr. Huggins says: "The partial phases of this eclipse furnished conditions which would put the success of the method beyond doubt if the plates showed the corona cut off partially by the moon during its approach to and passage over the sun. As the telegrams received from Grenada, and a telegram I have received this day from Dr. Gill, at the Cape of Good Hope, state this partial cutting off of the corona by the moon is not shown upon the plates, I wish to be the first to make known this untoward result. I regret greatly that a method which seemed to promise so much new knowledge of the corona, which, under ordinary circumstances of observation, shows itself only during total eclipses, would seem to have failed. At the same time I am not able to offer any sufficient explanation of the early favorable results."

Mr. Common thinks it probable that this failure to get a picture of the moon projected on the corona was due entirely to the state of the sky; and Professor Langley, in a recent letter to Nature (35: 53), adds his testimony as to the great effect of atmospheric diffusion upon the visibility of the corona. Moreover, Dr. Huggins says that he has not himself been able to obtain any satisfactory results since 1883, and that the plates taken by Mr. Ray Woods in 1884, in Switzerland, are inconclusive. The failure may be due to the abnormally large amount of air-glare from finely divided matter of some sort which has been present in the higher regions of the atmosphere since the autumn of 1883.

It is interesting to note that Professor Wright, of New Haven, in experimenting upon the visibility of the corona, succeeded in obtaining what he believed to be a coronal image upon a screen, when he, too, was brought to a standstill by these same "white skies" and "red sunsets." Professor Wright's method was to admit the sun's rays reflected from a heliostat, into a darkened room, and to cut out all but the blue and violet rays by a suitable absorbing cell, and then to form an image of the sun and its surroundings upon a sensitive fluorescent screen, stopping out the sun's disk itself.

Professor Young seems to have some slight hope of ultimate success of these efforts to reach the corona without an eclipse.



*Langley's observations of hitherto unrecognized wave-lengths.*—Professor Langley having traced the solar spectrum in the infra-red as far as wave-length = 0.0027 of a millimeter, where it suddenly ceased, has since, with more delicate instruments, examined the emission spectra of various terrestrial substances at temperatures from that of fusing platinum to that of melting ice, and more particularly of temperatures corresponding to the ordinary conditions of the soil. The result has been to show that the maximum of heat from cold and black bodies has in every case a wave-length greater than 0.0027—greater, that is to say, than that of the lowest solar heat which reaches us. Professor Langley thus sums up (*Am. J. Sc.*, 132 : 84–106) his investigation : “Broadly speaking, we have learned through the present measures with certainty of wave-lengths greater than 0.005 millimeter, and have grounds for estimating that we have recognized radiations whose wave-length exceeds 0.03 millimeter, so that while we have directly measured to nearly eight times the wave-length known to Newton, we have probable indication of wave-lengths far greater, and the gulf between the shortest vibration of sound and the longest known vibration of the æther is now in some measure bridged over.”

*The visual solar spectrum in 1884.*—Professor Piazzì Smyth made a careful map of the solar spectrum in 1884 in order to determine whether any perceptible effect had been produced by the “white skies” so prevalent in that year. His observations have lately been published in a series of sixty plates, in the *Transactions of the Royal Society of Edinburgh*, vol. 32. He finds that the red and violet ends of the spectrum show a marked general dulling, such as should arise from the upper air being laden with minute opaque particles—whether from the Krakatoa explosion or any other source.

*Thollon's map of the solar spectrum.*—M. Thollon, in the *Bulletin astronomique* for July, gives some interesting details in regard to the great map of the spectrum for which the Lalande prize of the Paris Academy was awarded him about a year ago. An earlier map from A to H was finished by Thollon in 1879, but he determined to go over the work again with improved instruments, and to make a chart representing, with all the accuracy attainable, the positions, breadths, and relative intensities of the lines, a chart which will enable us to determine in the future whether any changes have taken place. For even now, from the comparison of M. Thollon's chart with that of Ångström, there is a strong suspicion that some change has occurred in the intensity of several lines between B and C.

M. Thollon has carried the map from A to b, and it is to be continued to the violet by M. Trépied. It is now more than 33 feet long (though it covers little more than one-third of the spectrum), and contains about 3,200 lines, nearly 900 of which are distinguished as of telluric origin. The instrument employed was a large spectroscope with bi-



sulphide of carbon prism, kept at an even temperature by running water. The measures were made with a fine glass pointer.

*Cornu's device for distinguishing the telluric lines in the solar spectrum.*—At the meeting of the Royal Astronomical Society, on June 11, 1886, M. Cornu gave a description of an ingenious method he has devised for distinguishing between those lines of the solar spectrum which are atmospheric and those which are due to solar absorption. The east and west equatorial limbs of the sun are alternately thrown on the slit of the spectroscope by means of an oscillating mirror. As one limb of the sun is approaching us and the other receding, there is a real difference of wave-length in the same radiation as obtained from the two limbs, and consequently the solar lines appear to oscillate while the atmospheric lines remain perfectly stationary. "It is as if you shook the spectrum; and if a line were a solar one it moved, if a terrestrial one it remained steady."

*The absorption spectrum of oxygen.*—About three years ago M. Egoroff was able to show that the great groups A and B in the solar spectrum were due to the absorption of oxygen. More recently the  $\alpha$  band was also found to be due to the same gas. M. Janssen, studying the absorption of oxygen, has now discovered that, under certain conditions, the gas yields another spectrum, composed no longer of lines easily separated, but of shaded bands, which can only be resolved with great difficulty. This system of bands appears for moderate pressures much later than the spectrum of lines, but it shows itself very quickly with increase of the density; the two systems are so different that it is possible to obtain either the first without the second, or *vice versa*. M. Janssen was at first unable to explain how it was that these bands were not visible in the solar spectrum when they were easily obtained by passing light through thicknesses of oxygen far less than the sun's light has to traverse before reaching us. But further experiments showed that these bands did not develop in proportion to the thickness of the stratum of oxygen producing them, multiplied by its density, but in proportion to the thickness multiplied by the square of the density. The density of our atmosphere being small as compared with some of the pressures at which M. Janssen worked, the non-appearance of these bands amongst the telluric lines of the solar spectrum is readily explained.

M. Janssen is continuing his experiments at Meudon, and is building tubes which can be loaded with 1,000 atmospheres of hydrogen, oxygen, or carbonic acid. In this last case the real density of the gas will be superior to the density of water. (Nature.)

For a thorough and authoritative review of recent advances in our knowledge of the sun the reader should consult Professor Young's article which appeared in the Popular Science Monthly for November, 1886 (30:24-33), and also his "Ten Years' Progress in Astronomy," in vol. 5 of the Transactions of the New York Academy of Sciences.

THE PLANETS.

**MERCURY:** *The mass of Mercury.*—Dr. Backlund has published in the Bulletin astronomique for October a new mass of Mercury, obtained incidentally in his discussion of the motion of Encke's comet. The new result in question is  $\frac{1}{2668700}$ , the sun's mass being unity, and this is the largest value of the mass of the planet yet obtained. Dr. Backlund states that, even supposing the acceleration of the comet's mean motion to have been constant during the entire period, 1871-'85, it is not possible to represent satisfactorily the five apparitions of the comet during that period on the assumption of a mass of Mercury less than  $\frac{1}{5000000}$ .

**VENUS:** *Semi-diameter of Venus.*—Mr. Thackeray, discussing the observations of Venus made at Greenwich from 1866 to 1884, finds that the amount of personality in the measures is much greater than the correction due to the instrument, and that, though a greater number of observers by compensating one another might give increased accuracy to the value of the semi-diameter, it is just as likely that they should not.

**THE EARTH:** *Geodetic Congress.*—We learn from Nature that the International Geodetic Conference met at Berlin in October, 1886, to settle the organization of the central geodetic bureau (which is to have its permanent seat at Berlin), and to determine upon the best method of executing the resolutions passed at Rome and Washington in 1883 and 1884, respecting the actual measurement of a degree on the earth's surface. The adoption of Greenwich as a first meridian is to be strictly enforced, but the introduction of international normal time is postponed on account of insuperable practical difficulties.

*The proposed change in the beginning of the astronomical day.*—It is to be regretted that no agreement has yet been reached by astronomers upon the proposition to change the beginning of the astronomical day from noon to midnight.

The general sentiment is opposed to making any change until it is clear that it will be adopted by a majority of astronomers, and until the proper modifications have been introduced into our principal ephemerides. The new day has been provisionally adopted by Mr. Christie, at Greenwich, and the board of visitors have recommended that it be introduced into the Nautical Almanac for 1891. On the other hand, the superintendents of the German and American ephemerides oppose any change; and there seems to be great danger that the agitation of the question by the Washington Meridian Conference in 1884 may introduce new confusion rather than remove the old. At present there is little prospect of the plan meeting with anything like a general acceptance before the beginning of the next century.

*Theory of the moon's motion.*—Several valuable papers upon the lunar theory have been published by Hill and others. Reference should be made to the papers themselves, cited in our Bibliography.

Mr. Hill has received the gold medal of the Royal Astronomical Society for his laborious and masterly researches upon this difficult subject.

An interesting historical note on the inequalities of the motion of the moon which depends on the figure of the earth, is given by Professor Hall in the *Annals of Mathematics*, vol. 2, No. 5.

MARS: *The "canals" of Mars*.—M. Perrotin and his colleagues at Nice succeeded in recovering many of Schiaparelli's enigmatical "canals" at the last opposition of Mars, although the planet was seen under very unfavorable conditions. Its apparent diameter at this opposition was only 14'', against 25'' at the opposition of 1877, when the canals were discovered. The canals were made out by several observers at Nice, and were recognized as having the same general outline and position attributed to them by Schiaparelli in 1882. They seem, therefore, to be essentially permanent, forming a sort of network of grayish lines projected against the brighter equatorial regions of the planet. Compared with the thickness of the spider lines of the micrometer, the finest of these lines appear to have a width which corresponds to an arc of  $2^\circ$  or  $3^\circ$  on the surface of Mars. Some of them measure from  $50^\circ$  to  $60^\circ$  in length, and several are double, composed of lines strictly parallel, separated, according to Schiaparelli's estimate, by intervals of from  $6^\circ$  to  $12^\circ$ . All of this speaks well for the purity of the atmosphere at Nice, the excellence of the 15-inch Henry refractor, and the keenness of the observers.

During the study of the planet (from the end of March to the middle of June) some change seemed to be taking place near Kaiser Sea. On May 21 this region, from  $10^\circ$  to  $55^\circ$  north latitude, was hidden by a luminous veil somewhat softer in color than the continents, very much as if clouds in regular parallel bands were stretched across the planet from northeast to southwest. At moments these clouds became transparent, exposing the outline of the prolongation of Kaiser Sea. Other similar cloud phenomena were observed on subsequent days. M. Perrotin suggests that these phenomena were really produced by clouds or mists circulating in the atmosphere of Mars, and concludes that they are, in such case, the act of an element belonging to the atmosphere, or to the surface of the planet, susceptible of motion and modification in a comparatively short time.

Mr. Denning, who has been an attentive observer of Mars, has not been able to make out the canals in the detail assigned to them by Schiaparelli, although he has distinguished a large number of appearances highly suggestive of these configurations. Mr. Denning concludes a review of his recent observations of the planet (*Nature*, 34: 105) as follows:

"Many of our leading treatises on astronomy attribute a dense atmosphere to Mars, but nothing has been observed during my recent observations to corroborate this theory. It seems to me far more plausible



to assume that the atmosphere of this planet is extremely attenuated. The chief spots are invariably visible, and the phenomena occasionally observed are rather to be imputed to the vagaries of our own atmosphere than to that of Mars.

“Jupiter and Saturn are doubtless enveloped in dense vapors shrouding their real surfaces from terrestrial eyes. Their markings are atmospheric, though in some cases very durable, and constantly undergoing changes of aspect and displacements of position by longitudinal currents. On Mars a totally different nature of things prevails. Here the appearances described are absolute surface markings displaying none of the variations which are so conspicuously displayed on Jupiter. . . . It seems to me that the very pronounced character of the markings and their great permanency are quite opposed to the idea that the planet is surrounded by a dense cloud-laden atmosphere.”

Dr. Lohse has used, in observing Mars, a double-refracting prism, achromatized for the extraordinary ray; this prism, placed before the ocular of the telescope, brings out more sharply the details of the planet's surface by reducing the polarized light reflected from its atmosphere.

*Satellites of Mars.*—Professor Hall was able to observe the outer satellite, Deimos, on four evenings in March, 1886, but the inner satellite was seen only once, and was then so faint that no measurements could be made. Both little bodies were near their predicted places.

THE MINOR PLANETS.—Eleven minor planets were added to the list in 1886, the last one bearing the number 264; the brightest was of the eleventh magnitude. Seven of the new-comers belong to Dr. Palisa, making the total number discovered by him fifty-seven. Dr. Peters has now discovered forty-six and Dr. Luther twenty-three.

The dates of discovery and the names, as far as assigned, are given in the following table:

*Minor planets discovered in 1886.*

No.	Names.	Date of discovery.	Magnitude at discovery.	Discoverer.	Observatory.
254	Augusta .....	March 31, 1886.	13.5	J. Palisa .....	Vienna.
255	Oppavia .....	.....do .....	13.5	.....do .....	Do.
256	Walpurga .....	April 3 .....	12.5	.....do .....	Do.
257	Silesia .....	April 5 .....	13	.....do .....	Do.
258	Tyche .....	May 4 .....	11.3	R. Luther .....	Düsseldorf.
259	Aletheia .....	June 28 .....	12	C. H. F. Peters	Clinton.
260	Huberta .....	October 3 .....	13.5	J. Palisa .....	Vienna.
261	Prymno .....	October 31 .....	11.2	C. H. F. Peters	Clinton.
262	Valda .....	November 3 .....	12	J. Palisa .....	Vienna.
263	Dresda .....	.....do .....	12	.....do .....	Do.
264	Libussa .....	December 22 ..	11.5	C. H. F. Peters	Clinton.



Number 253, discovered by Dr. Palisa on November 15, 1885, has been named *Mathilde*.

*The influence of phase on the brightness of the minor planets.*—Dr. G. Müller, of the Potsdam Observatory, is led to believe from observations of seven asteroids with a Zöllner photometer, that there is a real connection between the phase of these bodies and their apparent brightness, and that Lambert's law of phase brightness does not apply to them. The planets are separated into two classes. In the first class, class, which embraces Vesta, Iris, Massilia, and Amphitrite, the changes in brightness are only perceptible as the planet approaches opposition, thus resembling Mars in their behavior; in the second, which contains Ceres, Pallas, and Irene, the changes in brightness seem to be coextensive with the changes of phase, giving a light curve, like that of the the moon or Mercury.

*The asteroid ring.*—M. A. Svedstrup gives in the *Nachrichten*, Nos. 2740–41, an interesting abstract of a recent investigation, for which he received the gold medal of the Royal Danish Academy—a statistical examination of the orbits of 198 of the small planets, considered as part of a cosmical ring around the sun. The orbit obtained for the “mean planet” shows an inclination of about  $6^\circ$  and a mean distance of 2.64. The mass of this fictitious planet corresponds to an apparent magnitude, at opposition, of 6.7.\*

*Relation of the asteroid orbits to that of Jupiter.*—Professor Newton points out the interesting fact that the plane of Jupiter's orbit coincides almost exactly with the mean plane of the orbits found for the first 251 asteroids, understanding by the mean plane, the plane whose pole is the center of gravity of the poles of the asteroid planes; the difference between the poles is, indeed, only  $30'$ .

JUPITER: *The “red spot.”*—The “great red spot,” some 30,000 miles in length by 8,300 in width, has now been the principal object of interest on the planet for eight years. It was faint during the last season, but far more conspicuous than in 1885. Professor Young obtained, from eight observations made between March 17 and June 29, 1886, a rotation-time of the spot of  $9^h 55^m 40^s.7 \pm 0^s.2$ , showing that the remarkable retardation of the period still persists. This is brought out by the following figures:

In 1879	Mr. Pratt made the period....	$9^h 55^m 34^s.9$
1880-'81	Mr. Hough made the period...	37.2
1882-'83	Mr. Hough made the period...	38.4
1883-'84	Mr. Hough made the period...	38.5
1884-'85	Mr. Hough made the period...	40.1
1886	Mr. Young made the period...	40.7

Professor Young, on re-reducing Mr. Pratt's observations of 1879, obtains  $9^h 55^m 34^s.05$ , and he finds from a series of observations made by Prof. C. W. Pritchett, in 1882,  $9^h 55^m 38^s.15$ . A small round white spot

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\*In the *Bull. astron.*, 3: 415, this is corrected to 6.0 magnitude.

observed at Princeton in March and April, 1885, gave a period of  $955^m 11^s.14$ . "It is noteworthy that although this spot was in a higher latitude (about  $50^\circ$  south) than the red spot, it yet rotates more rapidly." Professor Young remarked the apparent overlapping of the southern belt and the red spot which took place towards the end of March and the beginning of April, and which was seen by many English observers (Observatory, May, 1886, vol. 9: p. 188); but whilst admitting that it was impossible to say which was uppermost, he was inclined, in opposition to Mr. Denning's view, to believe the red spot to be the lower. Mr. Denning has pointed out that the apparent partial coalescence of the two markings was simply due to an arm of the southern belt overtaking the red spot, the former having a rotation period shorter by about  $19^s$  than the latter.

Mr. Denning finds evidence of regular recurrence in many of the prominent markings on this planet.

**SATURN:** *The satellites of Saturn.*—Professor Hall has finished a very important discussion of the six inner satellites of Saturn, and his work has been published as Appendix I to the Washington Observations for 1883. The observations of Professor Newcomb in 1874, and Professor Hall's own observations from 1875 to 1884, are given in detail; these are followed by the formation of equations of condition and their solution, and the work concludes with useful tables of the satellites' motions.

A remarkable result of the discussion is that the Washington observations of the five inner satellites can be satisfied within the limits of their probable errors by circular orbits. It was hoped that the observations would determine the positions of the lines of apsides with such accuracy that the motions of these lines would be known, and that thus we might obtain data for a new determination of the mass of the ring and of the figure of the planet. But the resulting circular orbits for the inner satellites make the position of a line of apsides indeterminate, and for the present the mass of the ring remains unknown.

The mass of Saturn has been computed from the elements found for Titan, Rhea, Dione, and Tethys with the separate results for the reciprocal of the mass, —

From Titan .....	3480.07 ± 1.138
Rhea .....	3450.43 ± 6.202
Dione .....	3463.68 ± 8.379
Tethys .....	3463.41 ± 10.629

or, the mean result from the four satellites, is

$$\text{Mass of Saturn} = \frac{1}{3478.7 \pm 1.10}$$

the mass of the sun being unity.

In a paper in the *Astronomische Nachrichten* (No. 2743) entitled "Comparison of the five inner satellites of Saturn made at Toulouse in

1876 and 1877," Professor Hall discusses the old method of observing these difficult objects by noting their conjunctions with the ends of the ring, or with some other marked feature of the Saturnian system, but concludes that the filar micrometer measures are at present among the best we have. He is inclined to think that the heliometer, if it can be made large enough, must be one of the best instruments for dealing with measurements of such objects as Saturn and Jupiter. This suggestion is being carried out by Mr. Asaph Hall, jr., in a series of observations of Titan with the 6-inch heliometer of the Yale College Observatory.

The following table represents the results of Professor Hall's investigations upon these satellites. The elements of Titan, however, and the values of the node and inclination of the ring are adopted from Bessel. Mimas, Enceladus, Tethys, Dione, and Rhea are assumed to move in the plane of the ring, and Hyperion in the plane of Titan.

*Elements of the satellites of Saturn, 1880.*

Satellite.	Mean daily motion.	Time of revolution.	Mean distance from Saturn.
	°	d	"
Mimas .....	381.99078572	0.9424311	26.80
Enceladus.....	262.73177276	1.37021875	34.40
Tethys .....	190.69838434	1.88779785	42.734
			"
Dione .....	131.53500629	2.7369140	54.734 ±0.0442
Rhea .....	79.69010973	4.5174991	76.537 ±0.0459
Titan .....	22.57700000	15.9454245	176.915 ±0.0193
Hyperion .....	16.919883	21.276742	213.98
Iapetus .....	4.53794773	79.3310152	515.5195 ±0.02645

Satellite.	Longitude of Peri-Saturnium.	Eccentricity.	Inclination to ecliptic.	Longitude of node.
			° ' "	° ' "
Mimas .....	Circular .....	Zero .....	28 10 16.7	167 55 5.9
Enceladus .....	do .....	do .....	28 10 16.7	167 55 5.9
Tethys .....	do .....	do .....	28 10 16.7	167 55 5.9
Dione .....	do .....	do .....	28 10 16.7	167 55 5.9
Rhea .....	do .....	do .....	28 10 16.7	167 55 5.9
Titan .....	268 37 56.0	0.02841836	27 33 56.7	168 10 34.8
Hyperion .....	83 37 55.2	0.1	27 33 56.7	168 10 34.8
Iapetus .....	353 14 56.5	0.027795	18 33 39.5	142 26 41.4

*The motion of Hyperion.*—Tisserand in investigating the case of two satellites moving around their primary in orbits but little inclined to each other has shown that if the mean motions are very nearly commensurable, and if the motion of one was originally circular and uniform, the perturbations caused by the other would have for their principal effect to transform this motion into motion in a Keplerian ellipse with a uniform rotation of the major axis. Applying this to the case of Hyperion perturbed by Titan, which has been investigated by Hall and Newcomb, and in which there is one of the nearest approaches to commensurability of mean motions to be found in the solar system, M.

Tisserand finds that his results agree closely with the facts of observation, the computed rate of retrograde motion of the perisaturnium of Hyperion being  $18^{\circ}.8$  per annum, whilst the observed quantity is  $20^{\circ}$ , and he also finds that his value of the mass of Titan ( $\frac{1}{10730}$ ) differs little from that obtained by Newcomb. (Observatory, November, 1886, 9:360.)

URANUS.—Observations of the planet made by Dr. H. C. Wilson at the Cincinnati Observatory in 1883 (recently published in *Astron. Nachr.*, 2730), seem to confirm Professor Young's observations (*Astron. Nachr.*, 2545), that the equator of the planet does not coincide with the plane of the satellites' orbits.

NEPTUNE: *Satellite of Neptune*.—Marth calls attention (*Month. Not.*, 46:507) to what appears to be a remarkable change in the position of the plane of the orbit of Neptune's satellite. He noticed that the orbit from the Malta observations of 1863-'64 did not agree with that from the observations of 1852. The node and inclination obtained by Newcomb in 1874 showed a movement in the same direction, and the motion of these elements is still further confirmed by the orbit recently published by Professor Hall from his own observations at Washington. The probable errors are so small that it seems hardly plausible or possible to attribute the change to systematic errors of observations. Mr. Marth calls for careful observations to strengthen the evidence.

#### REPORTS OF OBSERVATORIES.

The following account of the recent activity of astronomical observatories is compiled from all available sources, the "*Vierteljahrsschrift*" furnishing, as usual, the data for most of the observatories, although the latest reports there published are for the year 1885. I am indebted to the directors of many observatories for the direct communication of information in regard to the institutions under their control.

An alphabetical list of astronomical observatories, compiled by Mr. Boehmer, will be found in the *Smithsonian Report* for 1885.

M. Lancaster, of the Bruxelles Observatory, has published a useful directory of observatories and astronomers.

*Algiers Observatory* (1886).—The French Government has granted the funds necessary for the completion of the observatory, and two assistants have been sent to join M. Trépied. A time service has been organized for the cities of Algiers and Tunis, and the observatory will co-operate in geodetic work with field parties. Stellar photography will receive special attention. The observatory possesses a spectroscope by Thollon giving a spectrum 10 meters in length.

*Allegheny Observatory* (1886).—The work during 1886 has consisted of an extension of former researches on invisible radiations, and on the absorption and radiation of heat by the earth's atmosphere, and also of researches upon the absolute temperature of the lunar surface. In con-



nection with this latter investigation a new field of exploration has been opened in spectral regions, where the planet's own radiations towards space, of very great wave-lengths—exceeding one one-hundredth of a millimeter—are now for the first time found.

Professor Langley, in giving a portion of his time to the Smithsonian Institution, has not resigned the active directorship of the observatory, and all communications relative to the scientific or business affairs of that institution should be addressed to him at Allegheny as usual. Mr. F. W. Very continues at the observatory as senior assistant. Mr. Keeler is now at the Lick Observatory, and has been succeeded at Allegheny by Mr. James Page, jr.

*Amherst* (1885).—This observatory, named in honor of the Hon. Abbot Lawrence, was built in 1847, and has been employed chiefly for purposes of instruction. Professor Todd was appointed director in July, 1881, and his report covers the years 1881–1885, inclusive. The instruments of the observatory are: A  $7\frac{1}{4}$  inch Clark equatorial, a 3-inch Gambey transit circle, and a  $6\frac{3}{8}$ -inch Pistor & Martins transit instrument, with mean-time and sidereal clocks, chronograph, and subsidiary apparatus. The equatorial is provided with two small cameras for celestial photography. Observations are made of sun-spots, of the phenomena of Jupiter's satellites, occultations of stars by the moon, etc. The provisionally adopted position of the observatory is: Latitude,  $+42^{\circ} 22' 17''.1$ ; longitude,  $4^h 50^m 4^s.67$  west of Greenwich.

*Ann Arbor* (1886).—The observatory is known as the Detroit Observatory, having been founded through the liberality of citizens of Detroit. Valuable additions and improvements have been made by means of further contributions from the same source and from the city of Ann Arbor, and also by appropriations made by the board of regents of the University of Michigan, to which the observatory is attached. The building consists of a main part, with a movable dome, and two wings. The east wing contains the large meridian circle by Pistor & Martins and a sidereal clock by Tiede, of Berlin. The west wing contains the library of the observatory, a chronograph with Bond's new isodynamic escapement, and the smaller instruments. This wing connects with the residence of the director. In the dome is mounted a large refracting telescope, with an object-glass 13 inches in diameter, constructed by the late Henry Fitz, of New York.

Much attention is given to instruction in astronomy, and through the liberality of the legislature a small observatory for the purpose of instruction has been erected on the observatory grounds near the main building. It contains an equatorial telescope of 6 inches aperture and a transit instrument of 3 inches aperture, with zenith telescope attachment. A building near by contains computing rooms and rooms for observers, and a workshop where necessary repairs and attachments for the instruments can be made. A set of self-registering meteorologi-

cal instruments has recently been added. It consists of Hough's barograph and thermograph and an anemograph.

The observatory is under the direction of Prof. M. W. Harrington, who is assisted by Mr. J. M. Schaeberle and a meteorological observer. Professor Harrington has devoted considerable time during the past few years to photometric observations, especially of the asteroids. Mr. Schaeberle has made observations with the meridian circle.

The observatory plant is valued at about \$40,000, and the annual expenditures amount to about \$3,000. It should be mentioned that the American Meteorological Journal is edited here by Professor Harrington.

*Armagh* (1886).—Under the direction of Dr. Dreyer the Armagh catalogue of 3,300 stars has been published.

*Bamberg* (1886).—This observatory, founded by the will of the late Dr. Remeis, of Bamberg, who died in 1882, will be provided with a 7-inch heliometer, the largest instrument of its kind made. Dr. Hartwig proposes to take up the systematic investigation of stellar parallax, and the investigation of the physical libration of the moon.

*Berlin* (1885).—With the meridian circle, Dr. Küstner has observed a series of comparison stars for planets and comets, stars which have been occulted by the moon, stars for heliometer investigations, etc. There have been made in all 2,096 observations of right ascension and 1,936 of declination; the reductions are up to date. A new observing list, containing the Pulkowa "Zusatzsterne" and Argelander's proper motion stars—about 1,000 objects in all—was started in 1886. The transit has been used for observations of circumpolars, and also for continuing the observations upon seven selected pairs of stars, which are to furnish data for determining the constant of aberration. With the 9-inch refractor Dr. Knorre has observed a large number of comets and planets, and with the aid of his "declinograph" he has determined the positions of about a thousand stars, some as faint as the thirteenth magnitude. Dr. Battermann observed occultations with the 4.6-inch refractor. The investigations upon the movements of piers have given interesting results, and the clock which has been for four years in a hermetically sealed case, continues to perform most satisfactorily.

*Bonn* (1885).—The meridian circle was devoted, mainly, to continuing the Gesellschaft zone observations. Volume VIII, the Southern Durchmusterung, was published during 1886, and the printing of the twenty-four charts which are to accompany this work has been begun. The reduction of the zone work is not quite finished. The director, Dr. Schönfeld, has been assisted in observing by Drs. Scheiner, Deichmüller, and W. Luther. Dr. Scheiner was absent a considerable portion of the year, serving a term of military duty.

*Breslau* (1885).—The observatory, under the charge of the veteran Dr. Galle, is engaged in meteorological and magnetic work. Assistant, Dr. Lachmann.

*Buchtel College Observatory* (1886).—Professor Howe has devoted his time to instruction in practical astronomy. The cost of the observatory was about \$5,000.

*Bucknell University Observatory*.—Mr. William Bucknell has given the sum of \$10,000 for an observatory at Lewisburgh, Pa. A 10-inch equatorial has been ordered from Clark and a 3-inch transit from Ertel. The building is of brick, 25 feet by 150 feet, a dome 16½ feet in diameter surmounting the central tower.

The observatory, under the direction of Prof. W. C. Bartol, is to be used for instruction in practical astronomy, and will be ready in June, 1887.

*Chabot Observatory* (1886).—This new observatory, the gift of Anthony Chabot, esq., to the city of Oakland, Cal., is under the direction of Mr. F. M. Campbell. The instruments are, an 8-inch equatorial, with micrometer and spectroscope, a 4½-inch transit, chronograph, clocks, etc. The geographical position given (Sid. Mess., 5:286) is: Latitude,  $+37^{\circ} 48' 5''$ ; longitude,  $3^{\text{h}} 0^{\text{m}} 54^{\text{s}}.3$  west of Washington.

*Cincinnati* (1886).—The Cincinnati Observatory was founded in 1842 by an astronomical society, and was afterward transferred to the University of Cincinnati, of which it now forms one of the departments. A new building was erected in 1870 upon Mount Lookout, about 4 miles east and 2 miles north of the central portion of the city. The observatory grounds comprise 4 acres on the summit of the hill. The building is of brick; it consists of a central portion supporting the dome, and two wings, the western being furnished with meridian shutters, and the eastern containing the library.

The observatory possesses the Mitchel refractor of 11 inches aperture, made by Merz & Mahler, and supplied with a filar micrometer and a double-ring micrometer. The magnifying powers range from 90 to 1,500. There is also a portable equatorial of 4 inches aperture by Clark, with magnifying powers ranging from 15 to 250. The transit instrument, by Buff & Berger, has an aperture of 3 inches and is furnished with a latitude level and an eye-piece micrometer for measuring differences of declination. The total value of the instruments is estimated to be about \$12,000. The library contains over fifteen hundred bound volumes besides a large number of pamphlets.

The financial support is derived from a city tax, the yearly income from which is about \$5,000. This provides for the salary of the director, one assistant, and a janitor, the payment of the ordinary expenses, and the publication of results. The purpose of the observatory is both educational and scientific. Instruction in astronomy is given in connection with the university, and the observatory is also open to the public for the first hour of each evening.

The principal work of the past year (1886) has been the prosecution of the zone observations with the 3-inch transit instrument. In these zones about 4,000 stars between the declinations  $-19^{\circ}$  and  $-22^{\circ}$  have



been observed, most of them three times or more. The work of preparing this catalogue for publication is already commenced, and in the progress of the work Professor Porter has detected a number of interesting cases of proper motion. The catalogue will probably be issued during the coming year. A few observations of nebulae, double stars, and comets were also made during the early part of the year, but were suspended owing to the resignation of Mr. H. C. Wilson, assistant astronomer.

The work proposed for 1887 is the completion of the observations required for the zone catalogue, and after that the continuation of a series of charts of southern nebulae.

*Cointe* (1886).—The new observatory attached to the University of Liège, Belgium, is under the direction of M. Folie, the director of the Brussels Observatory. The instruments are a 10-inch equatorial and 6-inch meridian circle (diameter of circle about 31.5 inches), both by Cooke, with numerous smaller astronomical and geodetic instruments, and a set of magnetical and meteorological instruments. M. Folie is assisted by Dr. L. de Ball and M. P. Ubaghs.

*Columbia College Observatory* (1886).—The observatory is upon the top of the college library building, 100 feet above the level of Forty-ninth street, New York City. The 13-inch Rutherford equatorial, 3-inch transit, and zenith telescope are mounted in a room about 24 by 30 feet. The instruments rest upon solid piers of masonry, which are supported by heavy iron girders, the floors and ceilings nowhere touching the girders. The instrumental equipment embraces also a 5-inch equatorial (not mounted at present), a Troughton & Simms transit, spectroscope and subsidiary apparatus, clock, chronometers, portable transit, personal-equation machine, etc. The dome is by Waters & Son, of Troy, New York, and consists of a paper covering with wooden ribs. The shutters of the transit slits are also paper, and open by the action of springs.

Some trouble is caused by vibrations from the railroad trains (over one hundred a day) constantly passing within 100 feet of the building, but at times the instruments are very steady.

A careful redetermination of the geographical position of the observatory will be made, as the old longitude seems to be somewhat in error. It is also hoped to devote the Rutherford equatorial, which is supplied with a photographic corrector, to astronomical photography.

Professor Rees, the director, has but one assistant, and the greater part of his time is required to carry on a very complete course of instruction in practical astronomy, designed especially for training engineering students.

*Dearborn Observatory* (1886).—The Dearborn Observatory is the property of the Chicago Astronomical Society, but is upon ground leased to it by the now extinct University of Chicago, and may at any time be required to vacate. A new site has not yet been selected. Observa-



tions of Jupiter and of double stars have been made with the equatorial during 1886, and the necessary observations for furnishing time to the city of Chicago have been made with the meridian circle. A catalogue of two hundred and nine new double stars has been sent to the *Nachrichten*. It is expected that observations of double stars, Jupiter, and the satellites of Uranus will be kept up during the coming year. The instruments of the observatory are valued at \$30,000. There is no permanent endowment, and Professor Hough carries on his work without assistants.

*Deutz* (1885).—Herr Emil Mengerling established in 1884 a private observatory, the principal instrument being a 5-inch refractor by Reinfelder & Hertel. Physical observations of the moon and Jupiter have been made, and attention is being directed to astronomical photography and spectroscopy. Approximate geographical position: Latitude,  $+50^{\circ} 56' 33''$ ; longitude,  $+0^{\text{h}} 25^{\text{m}} 45^{\text{s}}.0$  west of Berlin.

*Dresden* (1885).—At Baron von Engelhardt's observatory observations were made of comets, nebulae, double stars, the phenomena of Jupiter's satellites, occultations by the moon, etc.

*Dresden* (1885).—Dr. Drechsler, of the "Mathematischer Salon," continues a series of meteorological observations begun in 1828.

*Düsseldorf* (1885).—Since 1847, 1,271 observations of 157 asteroids have been made.

*Frankfort-on-the-Main* (1885).—Herr Epstein continues his star-gauges and his observations of sun-spots.

*Geneva* (1885).—Four hundred and ninety-eight chronometers were tested during 1885, some of them showing an uncommon degree of excellence. Forty-two chronometers were entered on December 1, 1885, for a twelve-weeks' special trial of temperature compensation. M. Kammermann has employed the 10-inch equatorial in observations of comets, nebulae, and satellites. Meteorological observations are continued as in former years.

*Gotha* (1885).—Dr. Becker has given up the greater part of his time to the reduction of his zone observations. The equatorial which has received a new  $4\frac{1}{2}$ -inch objective by Reinfelder & Hertel, and has been thoroughly repaired, was remounted in October. A series of observations was made with the meridian instrument.

*Greenwich* (1886).—The annual report of the astronomer royal, Mr. Christie, was submitted to the board of visitors of the Greenwich Observatory on June 5, and gives an account of the progress and activity of the observatory for the year ending May 20, 1886. The regular work of the transit circle and the altazimuth has been continued, and very satisfactory results have been obtained with the apparatus for determining absolute personal equations brought into use with the former instrument some months ago. Spectroscopic observations include a considerable number made of the new star which burst out in the great nebula of Andromeda. The spectroscopic observations of Sirius indi-

cate, as in the last three years, a displacement of the F line towards the blue; this displacement would correspond to a motion of the earth towards Sirius at a rate of something more than 20 miles per second, though, from the nature of the observations, the amount of such a motion can not be considered as very accurately determined. For the year 1885 a photographic record of the sun's surface can be made out for three hundred and sixty days by filling up the gaps in the series of Greenwich photographs from photographs obtained in India and the Mauritius. Observations of comets and of casual phenomena have been made with the equatorials; and the magnetic and meteorological observations, the time-service, etc., have been kept up as in previous years. The full import of the statement that the reductions of the observations are keeping pace with their registration will be appreciated by all who are engaged in routine astronomical work.

In regard to the new equatorial Mr. Christie says: "The construction of an object-glass of 23 inches aperture and 28 feet focal length, with suitable tube, to be mounted on the southeast equatorial, has been authorized by the Government, and the necessary funds have been provided in the estimates. The work has been intrusted to Mr. Grubb, with whom I have arranged the details of the tube, which is to be of special construction, adapted to the conditions of the mounting, and available for spectroscopy and photography as well as for eye observations. Mr. Grubb proposes to provide means for readily separating the lenses of the object-glass to such a distance as will give the proper correction for photographic rays."

It is proposed to refit the 12 $\frac{3}{4}$ -inch refractor for astronomical photography by placing a combination of a convex flint and a concave crown lens about 2 feet within the focus, in order to correct the chromatic aberration of the objective for the photographic rays without alteration of the focal length.

*Grignon* (1885).—Observations of sun-spots and of the physical appearance of planets, etc.

*Hamburg* (1885).—Only one hundred and nineteen nights in the year were favorable for observing. Besides the meridian observations and the observations of planets and comets, a large number of chronometers have been tested. Dr. Schrader has left the observatory to take part in a scientific exploring expedition, and his place is filled temporarily by Dr. Wilhelm Luther. The time-balls at Cuxhaven and Bremerhaven have worked satisfactorily, the former having failed only four times and the latter five. The Hamburg ball has given more trouble, having failed, from various causes, twenty-one times during the year.

*Harvard College Observatory* (1886).—The forty-first annual report of the director covers the year ending November 1, 1886. About half the Paine bequest, or \$164,198, has become available for the support of the observatory; and the funds, which in 1875 amounted to \$164,067 and in 1885 to \$226,958, have now risen to \$398,046. This increase must for

the present be devoted to the publication of observations already made, and to effecting repairs in the buildings and instruments. A new mounting for the 15-inch equatorial is required, and Professor Pickering expresses the hope that at no distant day means may be found for replacing the present building by one better adapted to the requirements of modern astronomy.

The most important extension of the work of the observatory which has recently been made is in the field of stellar photography. With the aid from the Bache fund almost the entire visible sky has been photographed, and a large number of photographs of stellar spectra have been obtained. For continuing the researches upon a stellar spectra Mrs. Draper has lent the 11-inch photographic lens employed by her husband, the late Dr. Henry Draper, and has provided means for a new mounting at Cambridge, and for the proper reduction and publication of the results. This investigation has been referred to under "Astronomical photography."

The 15-inch equatorial has been used for photometric observations, observations of new comets, and of the new stars in Andromeda and Orion, and for experiments in photography.

The work projected for the meridian circle is now completed, and the reductions are being pushed as rapidly as possible. Volume XV, part I, containing the annual results for the fundamental stars, 1870-'79, and the individual results, 1883-'86, has been published; it includes also the results from the separate observations of stars belonging to various special classes, and the catalogue of 1,213 stars, separately issued in 1885. The second part of this volume will contain the catalogue of zone stars. Volume XVI (published) contains a tabular statement of the instrumental constants and a journal of the observations. A volume corresponding to volume XVI, but relating to the zone stars instead of the fundamental stars, and another, containing the observations for absolute right ascension and declination made from 1879 to 1883, will complete the work of the meridian circle still requiring publication. The resignation of Prof. William A. Rogers, who has had charge of this instrument since it was mounted in 1870, is greatly to be regretted. Professor Rogers has accepted the position of professor of astronomy at Colby University, Waterville, Maine, but will, however, superintend the reduction of his meridian observations and their publication.

The meridian photometer, Professor Pickering states, has given entire satisfaction, both in accuracy and in rapidity of work. (*See Photometry.*) A time-ball is dropped at the Boston post office, and the telegraphic announcement of important discoveries has been continued under the management of Mr. Ritchie. The report concludes with a list, embracing twenty-two titles, of contributions to astronomical literature made by officers of the institution during the year.



The following financial statistics, some of which may be found in further detail in the report of the treasurer of the university, will be of interest:

Value of grounds, Harvard Observatory .....	\$80,000
Value of buildings .....	25,000
Value of instruments .....	40,000
Endowment .....	398,000
Total .....	543,000

The available annual income, including gifts for immediate use, is \$22,000. The salary of the director is \$3,400, the use of the house being estimated at \$600 more. The sale of time signals brought in nearly \$3,000 during the year. The principal items of expenditure are—

Total expenditure for salaries, including that of director .....	\$12,000
Total expenditure for instruments .....	800
Total expenditure for publications .....	3,500
Repairs and improvements on buildings and grounds .....	940

The personnel includes Professor Pickering, the director; assistant, Prof. W. A. Rogers (resigned September 1, 1886); assistant, Prof. A. Searle; and Messrs. Wendell, Edmands, Ritchie, Gerrish, Gifford, and Metcalf; with six computers, ladies.

The Boyden fund, which was left for the purpose of astronomical research “at such an elevation as to be free, so far as practicable, from the impediments to accurate observations which occur in the observatories now existing, owing to atmospheric influences,” has been transferred to Harvard College and will be administered at the observatory. The fund at present exceeds \$230,000. Professor Pickering proposes to establish an experimental observing station in Colorado, but desires to occupy ultimately some high mountain peak in the southern hemisphere where observations—largely photographic, probably—can be carried on in co-operation with Cambridge. Information in regard to eligible sites south of the equator is much desired.

*Heidelberg* (1886).—Private observatory of Dr. Wolf. The principal instrument is a 6-inch equatorial; objective by Reinfelder & Hertel, mounting by Sendtner, of Munich. A photograph of the observatory is given in *Sirius*, vol. 19, Heft 12.

*Helsingfors* (1885).—Dr. Donner has continued to observe the moon, moon-culminating stars, and planets, with the large transit instrument. This instrument is to be remodeled by Repsold into a meridian circle. A portable transit of 6.9<sup>cm</sup> (2.7 inches) aperture by Repsold has been mounted in the prime vertical. The equatorial has been used for observing comets.

*Herény* (1885).—The mirror of the 10½-inch reflector having been resilvered by Professor Safarik, the instrument has been arranged for experiments in celestial photography. Herr von Gothard has succeeded in photographing several constellations, star-clusters, nebulae, and stellar spectra, but the work is still regarded as experimental. Spectro-



scopic observations and drawings of the planets have been continued as heretofore.

*Hillsborough, Ohio.*—Private observatory of Henry A. Pavey. Approximate position: Latitude,  $+39^{\circ} 12'$ ; longitude,  $5^{\text{h}} 31^{\text{m}}$  west of Greenwich. The instruments are a 4-inch equatorial by Benjamin Pike's Sons, with mean-time clock and chronometer, and other accessories. Physical observations of the sun and Jupiter have been made, and observations of the zodiacal light. Variable stars have been observed in accordance with the plan proposed by Professor Pickering.

*Kalocsa Observatory* (1886).—Dr. C. Braun has published a report of the observatory founded by Cardinal Haynald, archbishop of Kalocsa. The instruments are a refractor, by Merz, of 7 inches; another of 4 inches; a transit, by Cooke, of 2.3 inches; altazimuth, clocks, spectroscopes, photometers, etc. The latitude from geodetic observations is  $+46^{\circ} 31' 41''.92$ ; astronomical methods give it  $0''.07$  greater. The longitude is  $1^{\text{h}} 15^{\text{m}} 54^{\text{s}}.343$  east of Greenwich. A valuable series of sun-spot observations has been made and discussed.

*Karlsruhe* (1886).—The observatory at Karlsruhe (Baden) is still in a small, temporary, wooden building, the instruments having been removed in 1881 from Mannheim to the present quarters in Karlsruhe, where the observatory forms a part of the "Technische Hochschule." Unfortunately the financial condition of the Grand Duchy of Baden has thus far precluded the establishment of a thoroughly equipped observatory, which has been in contemplation. The temporary building has two small meridian rooms, and a dome. The instruments are: (1) a 6 inch refractor by Steinheil, lately remounted by Fecker & Co., of Wetzlar; (2) an old repeating circle by Reichenbach some years ago changed into a meridian circle by Hildebrandt & Schramm, of Freiberg; the telescope has an aperture of 81 millimeters (3.3 inches); the divided circle is 3 feet in diameter; (3) a large portable transit instrument by Bamberg, of Berlin; (4) two fine clocks by Holwii, of Amsterdam—one with break-circuit attachment; (5) chronographs, chronometers, etc.

The personnel consists, at present, of the director, one regular assistant, and a temporary assistant. The director, Dr. W. Valentiner, has begun with the meridian circle a series of observation of all stars down to the eighth magnitude between  $0^{\circ}$  and  $20^{\circ}$  of south declination, each star will be observed six times. So far about nine thousand observations have been made, and most of these have been reduced and published in parts 1 and 2 of the "Veröffentlichungen" of the observatory. The assistant, Dr. von Rebeur-Paschwitz, uses the refractor for observations of comets, occultations, etc.; his principal work is the micrometrical measurement of star-clusters; two groups will soon be finished. The filar micrometer has been carefully investigated. Herr von Rebeur has also completed an exhaustive discussion of comet 1882 I (Wells). The second assistant, Herr L. Stutz, makes regular observations with

the transit instrument for the time-service of the observatory, and also observes moon-culminations and right ascensions of the fundamental stars for the southern zones of the "Astronomische Gesellschaft."

*Kew* (1886).—The magnetical and meteorological observations and observations for time are kept up. Sketches of sun-spots projected on the photo-heliograph screen are made in order to continue Schwabe's enumeration.

*Kiel* (1885).—Observations with the meridian circle and equatorial are continued, the equatorial having been provided with a new registering apparatus. The catalogue founded on the Helsingfors Gotha zones is still unfinished.

*Lawrence Observatory*.—(See Amherst.)

*Kis-Kartel* (1886).—Private observatory of Baron Podmaniczky, near Budapest, Hungary. The principal instrument is a 7-inch refractor by Merz, with a mounting by Cooke. The work commences next year with double-star measures and physical observations of the sun, moon, and planets.

*La Plata Observatory* (1886).—The Government of the province of Buenos Aires is fitting up in La Plata an observatory which is to have a 31.5 inch reflector, an equatorial *coudé* of 17 inches, an 8-inch transit, a large Thollon spectroscope with objective of 9.8 inches, apparatus for celestial photography, and numerous smaller instruments. A time-service will be instituted, and a large amount of geodetic work will be done, including the measurement of an arc of a meridian. The observatory is to be under the direction of M. Beuf, late an officer in the French navy.

*Leipzig* (1885).—Dr. Harzer has gone to Pulkowa, and has been succeeded at Leipzig by Herr Schnauder. The zone observations and necessary reductions are being advanced as rapidly as possible. The equatorial has been used on comets and star-clusters.

*Leyden Observatory* (1885).—Prof. H. G. van de Sande Bakhuyzen's report is for the year ending September 15, 1885. The new 10½-inch equatorial, with objective by Clark, and mounting by Repsold, is ready for use. The 7-inch refractor was used for observations of comets. A series of measurements of artificial disks was made with Airy's double-image micrometer for the purpose of determining the systematic errors of the measures of the diameters of Mars and Uranus obtained in former years. The meridian circle was devoted to observations of fairly bright circumpolar stars. Some progress has been made with the reductions of the zone observations, 1874-'76.

*Lick Observatory* (1886).—The Lick Observatory will soon be counted as one of the active observatories of America. The formal opening and transfer to the University of California can not take place until the great telescope is mounted (probably in the summer of 1887), but Professor Holden already has one assistant at work—Mr. Keeler, who has been Professor Langley's assistant at Allegheny for a number of years.

The crown and flint lenses for the 36-inch objective arrived safely at Mount Hamilton on December 27, 1886, and have been packed away in a fire-proof vault in readiness for the mounting.

It is the intention to provide three lenses, the third a "photographic corrector" which can be slipped on in front of the other two. The Clarks found that the first piece of glass sent them for this lens showed signs of internal strain due to insufficient annealing, and the work of figuring was only undertaken at the risk of the makers, Feil & Co. The suspicion of strain proved well founded, for the disk burst into three pieces while upon the grinding tool. Another disk will be procured and should be ready by June 1, 1887. The cost of the objective was \$52,000. The photographic lens will add several thousand dollars to this. The recent death of Feil père may cause serious delay in obtaining the glass for the third lens.

The mounting is under way in the workshops of Messrs. Warner & Swasey, of Cleveland, Ohio, and will be delivered at Mount Hamilton in June, 1887, for \$42,000. It will contain many novel devices, among them an application of a modified form of the bicycle ball-bearings to the right ascension and declination axes, which will insure great ease of movement. The driving clock will have an electrical control.

The hemispherical dome of 70 feet interior diameter has been built by the Union Iron Works, of San Francisco, for \$56,800. The question of an observing chair has been met by adopting Grubb's plan of moving the floor vertically 16 feet. Some such arrangement becomes absolutely necessary when we consider that the "spectroscopic length" of the telescope is some 5 feet more than the visual length, and the photographic length some 8 feet less; the eye-piece may be 7 feet from the base of the dome when the telescope is pointed to the zenith, or it may be 35 feet in the horizontal position. The floor will be raised in four minutes with a perfectly parallel motion, by hydraulic rams. The cost of the floor will be \$14,500. A star spectroscope is to be made by Brashear, of Pittsburgh, for \$1,000, and the micrometer by Fauth, of Washington, for \$750.

The total cost of the observatory will be a little over \$500,000, leaving nearly \$200,000 available as a permanent endowment. The annual income of the observatory from all sources will be about \$20,000.

In the summer of 1886 Prof. G. C. Comstock made an investigation of the Repsold meridian circle and a preliminary determination of the latitude. The resulting latitude of the north dome is  $+ 37^{\circ} 20' 25''.2$ ; the longitude given by the U. S. Coast Survey is  $8^{\text{h}} 6^{\text{m}} 34^{\text{s}}.35$  west of Greenwich. A time-service is in operation over the whole Pacific system of railways from Ogden to El Paso. Volume 1 of the observatory publications is in press, and will be distributed in the early summer.

Professor Holden's plan for utilizing to the utmost the magnificent equipment under his charge must commend itself to every one. The plan is to relinquish the use of the 36-inch equatorial for certain hours



of each day to distinguished astronomers, specialists, who may wish to turn its enormous power upon some one of the many unsolved problems of astronomy. Such astronomers may be invited to visit the observatory for periods of several months, and will be given every possible facility. The legislature of California has provided money for a permanent support of the observatory.

*Lund* (1885).—Dr. Dunér is principally occupied with stellar spectra and variable stars. Herr Laurin has observed with the meridian instrument a number of stars with large proper motion.

*McCormick Observatory*.—Professor Stone's report for the year ending June 1, 1886, states that the 26-inch equatorial has been employed chiefly in examining and sketching southern nebulae. The nebula in Orion and the Trifid and Omega nebulae have received special attention; many others have been studied, and two hundred and thirty-three new nebulae have been discovered. "The features seen indicate that the performance of the instrument employed surpasses that of any of the great reflectors which have been used in the examination of nebulae." Double stars, comets, and occultations by the moon have also been observed. Observations with the small equatorial for the revision of the 23° zone are now practically completed. Electric lamps are used for illuminating the circles and field of the great equatorial, and have proved most useful. The 45-foot dome revolves as easily as when first erected.

The cost of the observatory building and instruments was about \$70,000, of which \$64,000 was the gift of Leander J. McCormick. A working fund of \$25,000 was given by William H. Vanderbilt, and an endowment of the directorship of \$50,000 was subscribed by the alumni of the University of Virginia.

Professor Stone is assisted by Mr. F. P. Leavenworth and Mr. F. Muller. Part 2 of volume I, on the great comet of 1882, and part 3, on the nebula of Orion, have been issued during the year.

*McGill College Observatory* (1886).—A most thorough discussion of a series of longitude observations by Professor McLeod, at McGill College, and Professor Rogers, at Harvard College Observatory, has been published: the resulting longitude of the pier of the transit instrument at McGill Observatory being  $4^{\text{h}} 54^{\text{m}} 18^{\text{s}}.513 \pm 0^{\text{s}}.043$  west of Greenwich. The center of the dome of the Harvard Observatory is assumed to be in longitude  $4^{\text{h}} 44^{\text{m}} 30^{\text{s}}.993 \pm 0^{\text{s}}.041$  west of Greenwich.

*Melbourne* (1886).—Mr. Ellery has published the first installment of observations of southern nebulae made with the great Melbourne reflector from 1869 to 1885. A description of the great 4-foot Cassegrainian reflector is given; and there are several lithographs of small nebulae. Some fine results have been obtained in photography both of the moon and of stars and nebulae.

*Mexico*. See Tacubaya.

*Milan*.—The 18-inch Merz-Repsold refractor was mounted and ready



for work in May, 1886. The 8-inch glass has been used for double stars, comets, etc. Messrs. Rajna, Porro, and Abetti have been engaged in geodetic work.

*Morrison Observatory* (1886).—The work of the equatorial for 1886 has consisted of a series of observations on comets Fabry, Barnard, and Finlay (reduced and published or ready for publication); physical observations of Jupiter and phenomena of Jupiter's satellites, with a few observations of occultations by the moon. The meridian circle can be used, at present, only for time observations and for the determination of such star-places as are needed in equatorial work. A daily and efficient time-service is maintained on railroads extending to St. Louis, Chicago, and Kansas City, and thence south and southwest. Meteorological observations are kept up with regularity.

Professor Pritchett has prepared a small volume of the unpublished observations of former years. This is now passing through the press, and will be distributed as soon as practicable. The expense of publication is borne by Mrs. Berenice Morrison-Fuller, the founder of the observatory.

The annual income of the observatory is \$2,160. This covers all expenses, including salaries. The director has no assistance, except that rendered by his daughters, and such as is afforded by a boy in handling the instruments and caring for the rooms.

*Munich* (1885).—The revision of Lamont's catalogue is progressing favorably. A number of stars from the southern *Durchmusterung* have been added to the observing list, to fill up gaps. Dr. Seeliger has finished a count of the stars in this southern extension of the *Durchmusterung* similar to the one already published for stars of the northern hemisphere. Dr. Bauschinger was obliged to devote two months of the year to "Militärische Verpflichtungen."

*Nice* (1886).—The refractor of 30 inches was provisionally mounted in August, and it is stated that the trials with it have given most excellent results.

*O'Gyalla* (1885).—The main work of the observatory has been the experimental determination of the mechanical energy of the radiations of thirty-four stars of the first and second magnitude. The spectroscopic "*Durchmusterung*" of a zone  $0^{\circ}$  to  $15^{\circ}$  is nearly completed. Sun-spots are observed regularly.

*Oxford University Observatory* (1886).—Professor Pritchard's report was read to the board of visitors on June 16. The photometric measurement of the magnitudes of an equatorial zone of stars has been undertaken. Attention will be given to astronomical photography—a department of work for which the observatory is well equipped—directing investigations to, first, the relation which exists between the photometric and the photographic magnitude of stars; second, the reliable uniformity of the photographic film; third, the amount of astronomical accuracy attainable on the same.

*Palermo* (1885).—New comets, shooting stars, solar spots, and protuberances have been observed; drawings have been made of the planets, and atmospheric phenomena have been studied.

*Paris* (1885).—The report of Admiral Mouchez, presented to the council on the 22d of January, 1886, gives especial prominence to the work in astronomical photography. A reproduction is given of a photograph of the Pleiades taken by the Henry Brothers, and also an illustration of the instrument employed. We have already referred to many of the interesting results obtained. Three instruments have been used for photography; the first (aperture 6.3 inches), the experimental instrument used in 1884, has been employed in photometric researches. The second is a smaller instrument, aperture 4.3 inches, for photographing large comets and extended groups of stars. The third is the equatorial of 13 inches aperture, with which the more important work has been done.

The routine work has not, however, suffered; in the meridian service over sixteen thousand observations have been made by sixteen different observers; the instrument devised by M. Lœwy, the *equatorial coudé*, has been used for the observation of comets and minor planets, and the time-service, meteorological department, etc., are all in a most satisfactory condition. The reductions for the great catalogue were completed up to 8<sup>h</sup> right ascension. The catalogue has been printed up to number 3,800.

*Plonsk* (1885).—Comets, double stars, etc., have been observed, and an interesting study of the atmospheric lines of the spectrum has been undertaken. Dr. Jedrzejewicz, the director, has made a new determination of the geographical co-ordinates of the observatory with the following result: Latitude,  $+52^{\circ} 37' 40''$ ; longitude,  $27^m 57^s.07$  east of Berlin.

*Potsdam* (1885).—Dr. Vogel's most interesting report occupies more than ten pages of the *Vierteljahrsschrift* (vol. 21, pp. 132–142). The instruments have been improved in many minor details, and several pieces of subsidiary apparatus have been added. Drs. Müller and Kempf have devoted considerable time to finishing the new determination of wave-lengths of the Fraunhofer lines. Drs. Vogel and Wilsing have been at work upon the spectra of new stars, spectra of comets, and spectra of solar spots and protuberances. Dr. Müller has made a number of photometric observations of the major and minor planets, while Dr. Wilsing has observed variable stars. Dr. Lohse has made a series of drawings of Jupiter, and has obtained one hundred and forty-six photographs of the sun; these latter, taken in connection with Dr. Spoerer's telescopic observations, will furnish ample material for the history of the spots. Dr. Lohse has also continued his series of photographs of star-clusters with gratifying success. Dr. Wilsing has carried on a very interesting series of experiments to determine the density of the earth. The third part of volume four and the fifth volume of the

Annals have been published. The library has increased to about thirty-seven hundred volumes.

*Prague* (1885).—Professor Safarik has devoted his attention to variable stars.

*Princeton* (1886).—The 23-inch equatorial has been used by Professor Young in micrometrical work upon close double stars, the satellites of Uranus and Neptune, the surface markings of Jupiter, and the details of Saturn. Comets are observed when they have become difficult objects for smaller instruments. Occasional spectroscopic observations are made of sun-spots, prominences, and comets. The institution has no endowment which would make it possible to undertake any extensive or continuous programme of work. The small observatory is used almost entirely for instruction in practical astronomy, this part of the work being under the immediate supervision of Professor McNeill.

*Pulkowa* (1886).—The annual report of Dr. Struve is for the year ending May 25, 1886. The great routine work, the determination of star-positions, has been continued as in former years. The 30-inch refractor, in the hands of Dr. Hermann Struve, has been employed in observing the faint double stars of Burnham's catalogue, the satellites of Mars, Saturn, and Neptune, the Maia nebula and Nova Andromedæ, which was easily visible on January 27. Dr. Hermann Struve speaks in the highest terms of the instrument, both as regards its optical power and its mounting, the movement of the dome, etc. Backlund has measured with the 4-inch heliometer the positions of Jupiter's satellites, for a determination of the mass of the planet and the orbits of the satellites. Hasselberg has been experimenting upon photography of the solar spectrum. The observatory has met with a severe loss in the recent death of Herr Wagner.

*Radcliffe Observatory* (1886).—Observations have been made of the sun, the moon throughout the lunation, occultations by the moon, and the phenomena of Jupiter's satellites. Volume 41, containing results for 1883, has been published.

*Rio Janeiro* (1886).—M. Cruls announces that the observatory is to be transferred to a new site, nearly on the same parallel as the present observatory, but two minutes of time farther west. M. Cruls has been commissioned by the Emperor of Brazil to have a photographic apparatus constructed similar to that at Paris, in order to co-operate in the proposed photographic survey of the heavens.

*Rousdon* (1886).—A private observatory erected in 1884 and 1885 by Mr. Cuthbert E. Peek at Rousdon, near Lyme Regis, Devon, England. The principal instruments are, a 6.4-inch equatorial objective by Merz, mounting by Cooke, a 2-inch Troughton & Simms transit, chronometers, etc. Beneath the equatorial room is a laboratory which is also fitted for photography. In 1886 the comets of the year and a list of long-period variables were observed, and transit observations were made for rating the chronometers. A volume containing observations of comets,



Nova Andromedæ, etc., and meteorological observations from 1882 to 1885 has been published.

*Smith College Observatory.*—Professor Todd includes in his report of the Amherst Observatory a brief account of an observatory, the construction of which he has supervised for the trustees of Smith College (for young women), at Northampton, Massachusetts. A one-story brick building is divided into an equatorial room, photographic dark-room, library, clock-room, and transit-room. The equatorial is of 11 inches aperture, the objective by the Clarks, and mounting by Warner & Swasey. Incandescent lamps are provided for the illumination of the circles and micrometers. The transit-room will contain a 4-inch meridian circle. The approximate position of the new observatory is: Latitude,  $+ 42^{\circ} 19' 7''$ ; longitude,  $4^{\text{h}} 50^{\text{m}} 32^{\text{s}}.9$  west of Greenwich.

*South Evanston* (1886).—Dr. Marshall D. Ewell has erected a small private observatory at South Evanston, Cook County, Illinois, 10.8 miles north of Chicago. The equatorial is a  $6\frac{1}{4}$ -inch Clark refractor mounted on a pier made of Portland cement and fine gravel so as to form practically a single piece of rock from top to bottom. The dome is 12 feet in diameter, built with ash ribs covered with tin, and turns on six iron wheels. The observatory is also provided with a  $2\frac{1}{4}$ -inch Troughton & Simms transit, sidereal and mean-time chronometers, and minor apparatus.

*Stockholm* (1885).—Investigations upon the motions of the different members of the solar system have absorbed the attention of the director and his assistants. The mean motions of the apsides of the planets Jupiter, Saturn, and Uranus are found to differ sensibly from the values assigned by Leverrier. Herr Shdanow has continued Gylden's researches upon the lunar theory, and Dr. Harzer has contributed a valuable memoir upon the motion of Hecuba.

*Strassburg.*—Dr. Schur, previous to his departure for Göttingen, where he takes Klinkerfues' place, published a report, dated May 6, 1886, supplementary to his annual report of July, 1885. The principal meridian work was upon southern stars in the extension of the Durchmusterung, and Auwers' eighty-three southern fundamental stars and refraction stars. The moon was observed with the altazimuth; comets with the refractor. Dr. Kobold succeeds Herr Schur. Dr. Winnecke has been retired, at his own request, on account of ill health.

*Tacubaya* (1885).—The Observatorio Nacional, formerly at Chapultepec, is now at Tacubaya, about 6 miles from the city of Mexico. The final value of the longitude of the large meridian circle, from exchanges in 1885 with St. Louis, is  $6^{\text{h}} 36^{\text{m}} 46^{\text{s}}.54 \pm 0^{\text{s}}.02$  west of Greenwich. (*Astron. Jour.*, 7: 62.)

*Tashkent* (1885).—The refractor was employed principally in observing sun-spots; comets and occultations were also observed. The meridian circle furnished the places of a number of comparison stars for



comets and planets. Geographical positions were determined for six towns in central Asia.

*Temple Observatory* (1886).—Observations of double stars have been continued, and spectroscopic observations to determine the motion of stars in the line of sight.

*United States Naval Observatory* (1886).—No material change has been made in the character of the work. Professor Hall has used the 26-inch refractor in observations of Saturn, of double stars, and of satellites; and also for determinations of stellar parallax. No deterioration of the objective has been noticed since it was repolished ten years ago.

The transit circle has been employed in observations of the sun, moon, planets, and such stars as are necessary to complete the data for a transit-circle catalogue, which will contain all of the miscellaneous stars observed since the instrument was mounted, twenty years ago. The reductions are somewhat behindhand on account of the inadequate computing force. The 9.6-inch equatorial has been used in the observation of comets, asteroids, and the occultation of stars by the moon; and the Repsold meridian circle at Annapolis temporarily, under the direction of the Superintendent of the Washington Observatory, in the observation of a list of southern stars. The revision of Yarnall's catalogue and the reduction of recent observations with the prime vertical instrument are progressing favorably. Photographs of the sun have been taken with the photo-heliograph used during the transit of Venus. Ninety-eight negatives showing spots were secured between January 11 and September 30, 1886.

The extensive time-service of the observatory is in an efficient state, and the chronometer tests inaugurated a few years ago have proved of great benefit to the naval service. Considerable attention has also been given to the examination of nautical instruments, thermometers, etc., for the Navy.

The volume for 1882, and Appendices I, II, and III to the volume for 1883 have been distributed.

Commodore Belknap was relieved from duty as Superintendent on June 7, 1886, by Commander A. D. Brown, and Commander Brown on November 15 by Capt. Robert L. Phythian.

The expenses of the observatory are met by annual appropriations from Congress, the naval officers (including professors) receiving the pay of their respective ranks. The pay of fourteen officers attached to the observatory December 1, 1886, aggregated \$31,400.

The specific appropriation for the observatory for the year ending June 30, 1886, contains the following items: For pay of three assistant astronomers, \$3,600; one clerk, \$1,800; instrument maker, \$1,500; four watchmen, \$4,880; assistant for the 26-inch equatorial, \$720; gardener, \$1,000; seven laborers, \$4,620; for miscellaneous computations, \$1,200; purchase of apparatus and material for repairs of instruments, \$2,500;

library, \$1,000; repairs to buildings, fuel, gas, furniture, stationery, and contingent expenses, \$3,900; freight on observatory publications sent to foreign countries, \$366. The entire annual cost of the maintenance of the observatory may, therefore, be put at about \$58,500;—\$50,700 being for salaries and wages, and nearly \$7,800 for other expenses. The item of salaries will vary considerably, of course, with the number and rank of line officers on duty, and it should be borne in mind that several of the officers are engaged upon work carried on at the observatory as a naval institution.

The sum of \$100,000 is now available for the erection of a new observatory, and the plans prepared six or eight years ago are being revised, with a prospect of beginning work upon the new buildings in the course of a few months. The total cost of the buildings is limited to \$400,000.

*Warner Observatory.*—Dr. Swift has confined himself to the discovery of new nebulae and the search for comets. The instruments are: A 16-inch Clark equatorial, provided with a filar micrometer and many convenient accessories; a 4½-inch comet-seeker, and a sidereal clock by Howard. A spectroscope, to cost \$1,000, has been ordered from Alvan Clark & Sons. A description of the observatory, with its instruments and work from 1883 to 1886, has been published as volume I of the observatory publications. This volume contains a list of four hundred and nine nebulae discovered since July 9, 1883 (it is stated that five hundred and forty have been discovered in all), a list of the Warner astronomical prizes, and the full text of the Warner prize essays on comets and on the red “sky-glows.”

*Vanderbilt University Observatory, Nashville, Tenn.*—This observatory is supplied with the following instruments:

Six-inch equatorial refractor, by T. Cooke & Sons, 8-foot focus, with hour circle divided to single minutes, and subdivided to 2<sup>s</sup> by opposite verniers; and declination circle divided to 10' and read by two verniers to 10". There is also a third vernier reading to 15", used for setting in declination, and read by the observer at the eye-piece with a small telescope. The instrument is supplied with eight eye-pieces, ranging from 60 to 600, and filar micrometer (bright field, dark wires only). A revolving disk with colored glasses gives a change of color of field,—a red one being found most useful, as it seems to permit observations of fainter objects with sufficient distinctness of the wires. A ring micrometer (not belonging to the observatory) is also used with the equatorial. A good driving clock gives a steady motion to the telescope. Two spectroscopes belong to this instrument—one, a direct-vision spectroscope by Merz & Mahler, the other by Grubb.

The equatorial room is surmounted by a hemispherical dome, revolving readily by hand on twelve pairs of wheels. The shutter is of light corrugated iron, in two sections; the upper section, two-thirds of the entire length, passes through the zenith to the back of the dome; the other part is drawn to one side, running on two light wheels, upon

a projecting platform. This instrument has been used during the past year in the observation of comets, nebulae, and the planets, and other miscellaneous work. Positions of all the comets have been obtained with either the ring or filar micrometer. Some experiments in celestial photography have been carried on, and good views of the moon obtained. The instrument cost about \$1,900.

A 4-inch meridian circle, by Ertel, with circles 26 inches in diameter, divided to 3'. On the east pier is mounted a frame carrying four microscopes which read the circle to 0".5. The reticule consists of thirteen vertical and two horizontal wires. The field or threads are illuminated at will. This instrument is reversible, and cost about \$1,400.

The chronograph is one of Warner & Swazey's latest designs, and is used with either the equatorial or meridian circle. Cost, \$375. The sidereal clock, by Dent, cost \$500. The mean-time clock, by Howard, cost \$400.

There is also a 3-inch altazimuth, by Cooke; and a 5-inch portable refractor, by Byrne. This latter instrument is not the property of the observatory. With it Professor Barnard has discovered a large number of comets.

The observatory building consists of a transit room, an equatorial room, and two computing rooms. The equatorial room is on the second floor, and is reached by a spiral staircase.

*Washburn Observatory* (1886).—This fine observatory possesses a 15½-inch Clark equatorial, with filar micrometer, a Repsold meridian circle, one sidereal and two mean-time clocks, a chronograph, chronometers, etc., besides the excellent 6-inch equatorial which formerly belonged to Mr. S. W. Burnham, and with which his first observations and measurements of double stars were made. This latter equatorial, together with a Fauth 3-inch transit, is mounted in a separate building of wood, called the students' observatory. The main building has, besides the rooms for the meridian circle and the large dome for the equatorial, a separate clock and computing room, a room for the electrical switch-board, time relays, etc., and a well furnished room for a library and director's study. There are also sleeping rooms for two assistants, one of whom is the meteorological observer whose records are printed in the annual volumes of the observatory. The officers of the observatory are a director, two assistant astronomers (one of whom is a lady), the meteorological observer, and a janitor. The library of the observatory is maintained by the generosity of the Hon. Cyrus Woodman, of Cambridge, Massachusetts, who has given, for this purpose, the sum of \$5,000. One half the yearly interest from this sum is available for the purchase of new books, the other half going to increase the principal until it reaches a specified sum. The "publications" are printed at the expense of the State, and are issued when circumstances warrant. Four volumes have already been issued, and a fifth is nearly ready for publication.



The entire outfit of the observatory, in instruments and buildings, is due to the munificence of the late Governor Cadwallader C. Washburn, and cost not far from \$50,000. A detailed list of the cost of some of the instruments is given in the volumes of publications of the observatory. All salaries and running expenses are paid by the regents of the university from the general fund. These have heretofore amounted to about \$5,000 annually.

After the departure of Professor Holden, in December, 1885, the assistants of the observatory, Mr. Milton Updegraff and Miss Alice Lamb, completed the observations and reductions of the three hundred and three star list, and the reading of the proof-sheets for the publication of volume IV (1885) of the observatory reports. During the early summer of 1866 a careful study of the division errors of special diameters of the meridian circle was undertaken; also of its horizontal flexure. Observations of the latitude made with the meridian circle since its first mounting show a discordance between circle east and circle west of about  $1''$ . The cause of this is now an object of study, and is believed to be mainly due to flexure. The large equatorial has been kept employed upon double stars, and in January, 1887, a series of measurements was made with its filar micrometer upon the position of Sappho (80) at opposition. An index to those stars in the six Greenwich catalogues not occurring in Flamsteed, has been prepared by Miss Lamb, and will be published in volume V.

The usual routine work of the observatory, such as controlling the clocks in the city of Madison, the time bells in the university recitation rooms, and the daily furnishing of time-signals to the railroads entering Madison, has been faithfully attended to. Professor Holden's successor as director of the observatory is Prof. John E. Davies.

*Washington University Observatory, St. Louis* (1886).—Instruction in theoretical and practical astronomy is the main object of the observatory. An extensive time-service is maintained, and the observatory co-operates with Government field parties in geodetic work. Prof. H. S. Pritchett has one assistant. The income is derived from the general university endowment and from the time-service.

*Woodside Observatory*.—Mr. Charles L. Woodside has a small private observatory at East Boston, Massachusetts, its approximate position being latitude  $+42^{\circ} 22' 39''$ ; longitude  $4^{\text{h}} 44^{\text{m}} 9^{\text{s}}$  west of Greenwich. The principal instrument is a silvered-glass reflector of  $6\frac{1}{2}$  inches aperture and 5 feet focal length; the mirror is by Brashear, of Allegheny, and the mounting by Mr. Woodside himself. This is to be devoted for several years to a careful and systematic study of the colors of all stars brighter than the sixth magnitude visible at Boston. Mr. Woodside has devised a method of computing occultations which he has described in the *Sidereal Messenger* for July, 1886.

*Yale College Observatory* (1886).—For the year ending June 1, 1886, Dr. Elkin reports progress in his work of triangulation in the Pleiades



with the 6-inch heliometer. He proposes to observe ten of the brightest stars in the northern hemisphere for parallax. Mr. A. Hall, jr., has been engaged in observations of Titan with the heliometer, with a view to a new determination of the mass of Saturn.

*Zürich* (1885).—Dr. Rudolf Wolf is occupied almost entirely with sun-spot statistics. He fixes the last “maximum” of spots at 1883.9.

#### ASTRONOMICAL INSTRUMENTS.

*Barometer coefficients for clocks.*—Dr. Hilfiker has determined the barometric coefficient—or the variation in rate for a change of 1 millimeter in the atmospheric pressure—for a Winnerl clock with gridiron pendulum comparing the Winnerl clock with the Hipp normal electric clock at Neuchâtel on each night of observation.

These comparisons, made between August, 1884, and September, 1885, give an idea of the influence of the mode of compensation upon the value of the barometric coefficient. The following table shows the results obtained at Geneva and at several other observatories for their normal clocks:

Place.	Compensation.	Barometric coefficient.
Neuchâtel .....	Winnerl, gridiron pendulum .....	0s. 010
Do .....	Hipp electric clock .....	0. 012
Fulkowa .....	Mercury compensation .....	0. 013
Leyden .....	do .....	0. 015
Berlin .....	do .....	0. 015
Zürich .....	do .....	0. 015
Washburn Observatory .....	do .....	0. 012

(Bull. astron., December, 1886.

*The new optical glass.*—Nature for October 28, 1886, contains an interesting account of the experiments of Professor Abbé and Dr. Schott in their endeavors to produce a glass of such chemical composition that it may be possible to make lenses free from the secondary chromatic aberration and other defects. For the microscope lenses already made of the new glass Professor Abbé claims great superiority in many important respects.

*Electric illumination.*—Prof. Ormond Stone, of the McCormick Observatory, uses for illuminating the circles and micrometer wires of the great equatorial, Edison incandescent lamps of one-candle power, run by what is known as the “Orne motor battery,” or by the “Edco battery,” the latter being used where a more continuous light is required. The success of the experiment here has resulted in the use of electricity, at least for circle illumination, at West Point, Yale and other observatories.

In the Greenwich spectroscopic observations, “a slip of metal coated

with Balmain's luminous paint, inserted immediately behind the measuring pointer, has been frequently employed to give a phosphorescent illumination of the field."

Gautier's mercury-basin for nadir and reflection observations, described in last year's report, has been tried at the Melbourne Observatory, and gives highly satisfactory results.

We have already referred, in the report of the Lick Observatory, to the completion of the 36-inch objective and its removal to Mount Hamilton.

#### MISCELLANEOUS.

*Astronomical prizes.*—At the meeting of the Paris Academy of Science on December 27, 1888, the Lalande prize was awarded to Dr. Backlund for his work on Encke's comet; the Valz prize to M. G. Bigourdan for investigation of personal equation in the measurement of double stars; the Damoiseau prize to M. Souillart for his theoretical researches on Jupiter's satellites, and an "*encouragement*" of 1,000 francs to M. Obrecht for his study of the application of photometry to the eclipses of Jupiter's satellites. The Bordin prize was awarded to M. R. Radau for his work on the theory of astronomical refraction.

The gold medal of the Royal Astronomical Society was awarded to Mr. G. W. Hill for his researches on the motion of the moon.

The Rumford medal of the Royal Society, the Rumford gold and silver medals of the American Academy of Arts and Sciences, and the Draper medal of the National Academy were awarded to Prof. S. P. Langley for his researches with the bolometer.

The Watson medal of the National Academy, with an honorarium of \$100, was awarded to Dr. B. A. Gould.

The Royal Society of Edinburgh awarded the Makdougall-Brisbane prize to Dr. Edward Sang for his communication on the need for decimal subdivisions in astronomy and navigation.

The Warner prizes, \$100 for each comet discovered (and announced under certain conditions), were conferred, in 1886, as follows: Mr. Brooks, \$300; Mr. Finlay, \$100; Mr. Barnard, \$100.

*The American Astronomical Society of Brooklyn.*—Among the papers read in 1886 were: "The Earth's Temperature," by H. M. Parkhurst; "Faye's Nebular Speculations," by G. P. Serviss; "Origin of Meteorites," by G. W. Coakley and H. M. Parkhurst. The president of the society is Mr. S. V. White, the secretary, Mr. G. P. Serviss, Brooklyn, New York.

*Baltimore Amateur Astronomical Society.*—A number of gentlemen of Baltimore have organized an amateur astronomical society, meeting each month for the presentation of papers and discussion of observations. Dr. Hooper, 1425 Linden avenue, the secretary, has a 5-inch Clark equatorial; Mr. Gildersleeve a 6-inch equatorial with object-glass by Dr. C. S. Hastings; Mr. Stahn a 4-inch glass, a so by Dr.

Hastings, and Mr. Numsen a 4-inch Cooke equatorial, mentioned in the report last year under the "Denmore Observatory." Physical observations are made of the sun, moon, planets, and comets. Mr. Stahl has kept a record of sun-spots, and has devised numerous ingenious accessories for his instruments.

*Astronomical Journals.*—The re issue of the "Astronomical Journal" by Dr. Gould is cordially welcomed, particularly by American astronomers, who are thereby furnished with a more prompt means of intercommunication than has been heretofore available. An interval of twenty-five years occurs after No. 144; and No. 145, bearing the date of November 2, 1886, begins volume VII. The Journal is edited by Dr. Gould, as before, at Cambridge, Massachusetts.

A new monthly astronomical review, *Revista do Observatorio*, has appeared, under the editorship of Dr. Luis Cruls, of the Imperial Observatory of Rio Janeiro. The journal will be found interesting and valuable by amateurs and those interested in the progress of astronomy, as well as by professional astronomers.

We are at the same time obliged to record the discontinuance of the *Astronomical Register*, with the completion of its twenty-fourth volume, December, 1886, No. 288.

*The Influence of astigmatism on Astronomical Observations.*—It appears from Professor Seeliger's researches that this malformation in the eye, which is far from uncommon, exerts a greater influence on astronomical measurements than is generally supposed. Thus, he shows that a systematic error in a series of observed declinations amounting to  $0''.26$  may very well be due to it; and it appears that the discordances in observed position angles of double stars—depending on the inclination of the line joining the components to the vertical—with which the measures of some observers are affected, may be referred to the same cause. (*Nature*, November 18, 1886.)

*Determination of time.*—Döllén has described in the *Nachrichten* (114: 289) an expeditious method of obtaining a clock correction where great refinement is not necessary. The observation is made in the vertical of the pole-star, and tables have been published by the Pulkowa Observatory giving for some sixty odd stars all the quantities which are independent of the latitude, required in the formulæ. The work of reduction is made as brief as possible.

*An astronomical directory.*—M. A. Lancaster, the librarian of the Brussels Observatory, has published a very useful list of observatories, their geographical co-ordinates, and the astronomers attached to them; of astronomical societies and institutions, and of reviews and journals specially devoted to astronomy. The little book contains also a list of names and addresses of astronomers not attached to any observatory, and of amateurs, as well as a list of makers of astronomical instruments.

Miss Clerke's admirable "Popular History of Astronomy during the

Nineteenth Century" has been so widely reviewed that it seems unnecessary to do more than merely to mention it by title here. The book is "untechnical," and the "terse and vigorous" style makes it most interesting from beginning to end. There are numerous references to the original sources of information.

Professor Young's "Ten Years' Progress in Astronomy" has been reprinted in the *Sidereal Messenger* (vol. 6) and *Nature* (vol. 35).

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It is hoped that the abbreviated titles of journals will be intelligible without special explanation. ("Compt. Rend." is, of course, the *Comptes rendus hebdomadaires des séances de l'Académie des sciences*, Paris, and "Month. Not." the *Monthly Notices of the Royal Astronomical Society*.) Among the imprint and other abbreviations there occur:

Bd. = Band.	n. F. = neue Folge.
d. = die, der, del, etc.	n. s. = new series.
ed. = edition.	p. = page.
hrsg. = herausgegeben.	p* = page of this summary.
il. = illustrated.	pl. = plates.
k. k. = kaiserlich königlich.	pt. = part.
Lfg. = Lieferung.	Rev. = Review.
M. = mark.	s. = series.
n. d. = no date.	sh. = shilling.
n. p. = no place of publication.	v. = volume.

The alphabetical arrangement is made to serve as an index to the present record, by inserting after the subject-heading, the pages of this review (p\*—) on which the different subjects are noticed.

In the references to journals the volume and page are simply separated by a colon; thus: 5:81 indicates volume 5, page 81.

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AUERBACH (CARL HEINRICH, AUGUST); b. February 24, 1813, at Berlin; d. at Gohlis, October 22, 1886, æt 73.

BASSNETT (THOMAS); d. February 26, 1887, æt 79.

BOILEAU (Gen. J. T.); b. May 26, 1805, at Calcutta; d. November 9, 1886, æt 81.

DORNA (ALESSANDRO), director of the Turin Observatory; b. February 13, 1825, at Asti; d. at Borgo San Pietro, near Turin, August 19, 1886, æt 61.

FELDKIRCHNER (CHRISTOPH), first assistant at the Munich Observatory; b. February 26, 1823; d. March 1, 1886, æt 63.

HOÜEL (JULES), professor of mathematics at Bordeaux; b. —, 1823, at Thaon; d. June 14, 1886, at Périers, æt 63.

KRAPOTKIN (ALEXANDER); b. —; d. at Tomsk, August 6, 1886, æt 45.

MAYWALD (GUSTAV ADOLPH RICHARD), computer on the *Berliner Jahrbuch*; b. February 13, 1817, at Leuthen; d. July 19, 1886, æt 69.

VON OPPOLZER (THEODOR); b. October 26, 1841, at Prague; d. December 26, 1886, at Vienna, æt. 45.

PEARSON (*Rev.* JAMES); b. 1826, at Preston, England; d. April 8, 1886, at Fleetwood, æt. 60.

SAXBY (*Rev.* STEPHEN HENRY); b. ---, 1831; d. August 5, 1886, æt. 55.

TALMAGE (CHARLES GEORGE), director Leyton Observatory, b. November 12, 1840, at Greenwich; d. March 20, 1886, at Knots Green, Leyton, æt. 45.

WAGNER (AUGUST), vice-director Pulkowa Observatory, b. September 10, 1828, at Nurft; d. at Pulkowa, November 14, 1886, æt. 58.





# NORTH AMERICAN GEOLOGY FOR 1886.

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By NELSON H. DARTON.

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## INTRODUCTORY.

The preparation of this review was undertaken by the writer with serious misgivings as to his ability either to complete it in the time allotted, or to reduce the results of a year's activity in the various branches of geologic research to the space assigned; and the outcome is in several respects unsatisfactory.

It was originally intended to include a bibliography of North American geology for the year 1886; but as the work progressed, this was found to be impossible without greatly exceeding the space assigned to the review. It was, however, believed that the bibliography would be of such value to the geologists of this and other countries as to warrant its separate publication. Accordingly, it was annotated, so modified as to include a subject-index under the same alphabetic arrangement as the author's bibliography, and so extended as to become exhaustive for North America; and thus modified it will form Bulletin No. 44 of the U. S. Geological Survey.

It was originally intended, also, to include in this review a résumé of the foreign contributions of the year to geologic philosophy; but this, too, finally proved impracticable, partly on account of the inaccessibility of much of the literature, and partly on account of the limits of space and time.

By reason of hurried preparation, the abstracts in this review are often less full than seems desirable, and by reason of the character of the material the abstracts are generally presented more or less disconnectedly. It is believed, however, that all important publications distributed during 1886, or bearing that date and received early in the present year, are noticed in the following pages. With the exception of a few words of introduction or connection, the writer has acted simply as an abstractor, and has endeavored to avoid bias or partiality.

## QUATERNARY.

1. No subject in American geology is now receiving more attention than that including the many interesting problems of the Quaternary. Each year brings forth a considerable mass of literature in which con-

tributions are made to this subject. In an address before the American Association in 1886, Chamberlin\* summarized the results attained up to that time, especially those relating to drift phenomena. The following is a very brief abstract of his conclusions: Three phases are recognized in the course of the undulatory drift border: (1) a thickened edge or terminal moraine; (2) a thin margin; and (3) an attenuated border of scattered pebbles. The morainic border prevails from the Atlantic to the Ohio, while attenuated borders reach thence to the Rocky Mountains. Attenuated borders delimit an earlier ice-incursion, and the morainic border a later one. The interval between the two principal glacial epochs is represented by changes of orographic attitude and drainage; by different degrees of erosion, decomposition, and ferrugination; and by vegetal accumulations and lacustrine oscillations. The chief interglacial epoch was marked by great erosion. The drifts are grouped into the earlier, embracing two or more subdivisions, and the later, embracing several subordinate phases; also a third series, embracing the Great Basin deposits of aqueous origin. Of bowldery clays at least three genetic classes are recognized: (1) the subglacial; (2) the englacial or superglacial; (3) the subaqueous; and perhaps (4) tills ridged transversely by the thrust of the margin of the ice. Of moraines, terminal, lateral, medial, and interlobate are described; and of forms of ground moraine the following are enumerated: (1) till tumuli; (2) mammillary and lenticular hills; (3) elongated parallel ridges; (4) drift billows; (5) crag and tail; (6) pre-crag and combings; and (7) veneered hills; the first three being grouped under the term "drumlins." Of the assorted drifts, two classes commonly embraced are excluded: (1) the "orange sands," commonly regarded as Champlain deposits, because there is great uncertainty in regard to their age, and good reason to believe that they are not Champlain; (2) drifts reworked by non glacial agencies. Omitting these, two classes there are recognized; (1) those that gathered immediately within and beneath the ice body itself, or against its margin, and (2) those borne to distances beyond its limit by glacial drainage. Of the first, there are the products (*a*) of superglacial streams; (*b*) of moulins; (*c*) of subglacial streams; (*d*) of streams in ice-cañons; and (*e*) debouchure deposits at the glacial margin. The importance of the distinction between kames and osars is urged. Of valley drift the intermediate phases are passed over, and attention is directed to two extreme phases: (*a*) the moraine-headed valley trains and (*b*) the loess, the former the deposit of vigorous glacial floods, the latter inferred to be the product of slack drainage. Attention is directed to the ice-blocked ancient lakes, especially of the greater basins, to the overflow phenomena, and to the difference between ancient and existing water levels. Finally, the current interpretations of glacial phenomena, and specula-

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\* Am. Assoc., Proc., vol. 35, pp. 195-211; Science, vol. 8, pp. 156-159,

tions respecting the origin of the glacial epoch are discussed, and the hypothesis that the regional refrigeration of the glacial time was brought about by shifting of the terrestrial poles is favorably presented.

2. In a paper on "North America in the Ice Period"\* Newberry discusses the iceberg theory and glacial climate, and states very forcibly the objections to the former and to Whitney's theory of the latter. It is shown that the iceberg theory is inapplicable to the mountainous districts of the West, and can not be reconciled to such phenomena in the East as (1) the widely different altitudes of glaciation within short distances; (2) the entire independence of the principal glacial features of altitude in the vicinity of the terminal moraine; (3) the driftless area of Wisconsin; (4) the complete absence of marine shells in the inland drift deposits; and (5) the characteristic effects of the erosion when compared with glaciers now in existence.

3. Branner makes some very interesting observations on the relation of topography to the glacial flow in the Wyoming and Lackawanna valleys, Pennsylvania, a district of sharp relief and numerous rock outcrops. Two systems of striæ are found, one parallel to the general southward slope of the country, and produced by the flow of the great mass of ice in that direction, and another system determined entirely by the local topography, and apparently due to the effect of the latter upon the ice sheet when it was greatly reduced in thickness.†

The same writer‡ discusses the greatest elevation of glaciation in northeastern Pennsylvania, finding that the glacier overrode peaks 2,200 feet in height, which White and Lewis considered islands above the level of glaciation. These peaks are the Elk Mountains. Careful search has revealed unquestionable glacial striæ on one of their summits.

4. Britton§ finds driftless areas at a moderate height on the serpentine hills of Staten Island, a few miles north of the terminal moraine, which indicate a thickness of the ice of less than 200 feet.

5. In a paper on the geology of Cincinnati,|| James gives some interesting information on the local surface geology of that district, and, in view of the absence of glacial drift from the tops of some of the hills, doubts White's estimate that the glacial dam of the Ohio stood 645 feet above low water, as these hills are only 460 feet above at the highest point.

6. Salisbury discusses the distribution of drift copper in the Northwest. As far as reported, it occurs over an area of nearly half a million square miles, extending as far as 600 miles south, and several hundred miles east and west, of Lake Superior. Fragments are especially plentiful at

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\* Popular Science Monthly, vol. 30, Nov., 1886, pp. 1-11.

† Am. Phil. Soc. Proc., vol. 23, pp. 337-357.

‡ Am. Jour. Sci., III, vol. 32, pp. 362-366.

§ Nat. Sci. Assoc. of Staten Island, Proc., October, 1886.

|| Cincinnati Soc. Nat. Hist. Jour., vol. 9, pp. 20-31 and 136-149.



Grand Traverse Bay, at the mouth of the Illinois River, and along the lower part of the Wabash; but this may be due to fuller records from these places. In general, it is found that the size of the masses decreases as their distance from the Lake Superior region increases, and it is thought that, with some possible local exceptions, the latter has been its source.\*

7. In a paper on the geology in the vicinity of the Northern Pacific Railroad, Newberry† gives an account of his observations on the drift. In the Yellowstone Valley he was unable to find the evidences of the eastern drift reported by C. A. White, and considers the drift of the upper Missouri local in character.

8. Comstock describes some features of the drift in the Rocky Mountains of Wyoming and Colorado. All the glacial action is inferred to have been local, but intense. In the San Juan district, and to a less extent elsewhere, a "distinct peculiarity lies in the duplex character of the erosion; that is to say, there are two zones of glaciation vertically, the upper largely representing the transportative action, the lower being eroded without removal of the débris to any extent. The imperfect drainage had fastened the ice sheet so that it could move as a unit only in the superficial portion, while the lower part acted like a slowly working plow, which cut deeply but not so extensively as the overlying mass. In the more elevated tracts, therefore, the lower portion often lies in grooves like *culs-de-sac*, and many of these exist to-day, connected with the main drainage often by reversed or indirect drainage."‡

9. In his paper on the Post-tertiary elevation of the Sierra Nevada, Le Conte incidentally discusses the later history of the Mississippi Basin. He concludes that during the Champlain period it was filled with 400 feet or more of deposits; that in the terrace period elevation took place, and the present wide channel was cut,—not by cliff erosion as in the Grand Cañon, but by shifting of the stream from side to side, and that in the present epoch there has been subsidence and, as shown by Hilgard, a refilling with about fifty feet of alluvium.§

10. In a paper on the Geology of Long Island, F. J. H. Merrill makes the interesting statement that the morainal hills owe their elevation in great part to a series of folds at right angles to the course of the glacier, and involving the pre-glacial deposits. The deep bays in the north shore of the island appear to have been plowed across these flexed beds, and are found to be heavily flanked by ridges and hills. From the thinness of the till deposits south of Long Island Sound (except opposite its western extremity) it is thought that the depression was pre-glacial, and the ice sheet lost the loads of detritus in its lower portion and attached to its base in passing over the broader part of the Sound, only carrying across the bowlders and débris upon its surface. The

\* Wisconsin Acad. Sci., etc., Trans., vol. 6, pp. 42-50.

† New York Acad. Sci., Annals, vol. 3, pp. 242-270.

‡ American Naturalist, vol. 20, Nov., 1886, pp. 925-927.

§ Am. Jour. Sci., III, vol. 32, pp. 167-181.

stratified beds composing the greater mass of the formations of the island are unconformably overlain by the drift, but although they yield some fossils, their age is considered uncertain. Some of the clays exposed along the north shore may be Cretaceous, and other clays and sands are thought to be Tertiary, while the greater mass of the stratified sands and gravels are thought to represent the Post-pliocene of Sankaty Head and Gardiner's Island.\*

11. The same author reports the preliminary results of a detailed study of the Quaternary and recent formation of the coast region of New Jersey, made under the direction of the State geologist, Professor Cook.† An account is given of the subsidence of the coast and the variations in its rate. It is found also that the ocean shore is wearing away and the winds and waves cause its recession westward. Beach and strand formation is discussed, and descriptions are given of the several beaches and their recent changes.

12. In the introduction to this report‡ Professor Cook discusses the terraces of the coastal plain. They occur from 40 to 60 feet above tide, and it has been determined that they slope southward at the rate of three inches to the mile. It is thought that the higher terraces mark the position of the ocean level at the close of the glacial period, and that there has been an uplift between that time and the present subsidence.

13. On the northeastern corner of Staten Island Britton finds the morainal beds capping the finely stratified sands and clays along a line of contact between 25 and 30 feet above tide, indicating at least that amount of elevation since the glacial period, but there are other deposits of pre-glacial drift of much greater elevation on the island, and some other areas have been recently discovered.§

14. In a paper on the geology of Washington and vicinity, McGee gives an account of the Quaternary formations of that district. The city lies on the terraces of an amphitheater extending back from the Potomac. Up to an elevation of about 100 feet there is found a well-defined Quaternary deposit to which the name Columbia formation is applied. Its upper portion consists of loam or brick clay, varying from nothing to 20 or 30 feet in thickness; and its lower, of sand, gravel, and boulder beds, from a trifle to 20 feet in thickness, all more or less stratified throughout. It is thought that it represents a subaqueous delta of the Potomac River, deposited during the period of formation of the terraces. Its absence from above tide on the eastern side of the amphitheater is attributed to a dislocation bounding the coastal plain, of which other evidence is also found.||

\* New York Acad. Sci. Annals, vol. 3, pp. 341-364.

† New Jersey Geological Survey, Annual Report of the State geologist for 1885, pp. 61-95.

‡ *Ib.*, pp. 55-61.

§ Nat. Hist. Soc. of Staten Island, Proc. April, 1886.

|| District of Columbia, Report of the Health Officer for 1885, pp. 19-21, 23, 24, 25; Am Jour., Sci. III, vol. 31, pp. 473-474.

15. Smith describes a bed of clay inclosed in the Delaware gravels near Philadelphia. It contains remains of trees of species now living, and appears to be similar in age to the other clay beds farther up the Delaware valley.\*

16. Dwight describes some very curious structural features in Champlain deposits in the Hudson valley near Newburgh. At the locality described there are three huge clay-filled pot-holes in a sand bed. These holes are in line, close together and elliptical in outline, with their longer axes at right angles to the Hudson. They appear to be in a faulted block of the sand, and the fault line on one side is marked by a hard wall composed of sand cemented by carbonate of lime.†

17. Ashburner and Hill‡ describe the buried valley of the Susquehanna between Pittston and Kingston, in Luzerne County, Pa., and discuss the former channel of that river and its peculiarities. Ashburner describes the Archbald pot-holes in the same vicinity, and from their position considers them either due to water flowing beneath the glacier or over its edge.§

18. Dawson describes the boulder drift and sea margins at Little Metis, Lower St. Lawrence. The boulder drift occurs in belts exposed at low tide, and extending out to some distance from the shore. The first or shore terrace seldom holds boulders, but farther inland there is a terrace 30 feet higher, consisting of sand resting on hard boulder clay or till, the latter sometimes being filled with boulders and at others with marine shells. Higher up huge boulders are found perched upon the bare rocks, the latter being rough and showing no sign of polishing except near the second terrace. It is thought that these phenomena can not be ascribed to land ice, and are similar to those of the Lower St. Lawrence generally, except in some lateral valleys on the northern shore, where local glaciers appear to have descended.||

19. Lamplugh describes the glacial shell beds of British Columbia, adding detail to Dawson's previous descriptions. The beds at Esquimault, Vancouver's Island, lie in a gully in polished and striated diorite. The shells are abundant in the lower layers of the clays, and decreasing in number upward, are absent ten feet from the surface. It is thought that the beds were shoved up into this gully by the ice in its flow down the channel, as they dip steeply shoreward and are often disturbed.¶

20. Gilbert has discussed two instances of post-glacial deformation. First, in a paper on the inculcation of scientific method by example, he incidentally investigates the cause of the elevation of the center of the Bonneville Basin. It is supposed that this great Quaternary

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\* Philadelphia Acad. Sci. Proc. vol. 37, pp. 253-254.

† Vassar Bro's Inst. Trans., vol. 3, pp. 86-97.

‡ Second Geological Survey of Pa., annual report for 1885, pp. 637-647.

§ *Ib.*, 615-637.

|| Canadian Record of Science, vol. 2, pp. 36-38.

¶ Geol. Soc., Quarterly Jour., vol. 42, pp. 276-286.



lake slightly depressed the earth's crust, and that on its evaporation the normal conditions were resumed and the lake bed and terraces elevated.\* The same writer called the attention of the American Association to several small anticlinal ridges in the rocks of western New York, which are believed to have resulted from horizontal expansion of superficial strata consequent on post-glacial amelioration of climate.†

21. *Niagara Falls*.—At the Buffalo meeting of the American Association there was a general discussion of the various questions connected with the chronology of Niagara Falls, which was taken part in by Gilbert, Chamberlin, Hall, Pohlman, Claypole, Woodward, Wright, Davis, Comstock, and Holly. It was shown by Gilbert that the Niagara River probably began its work at the close of the glacial period, when the retreating ice opened the St. Lawrence Valley and separated the two lakes, Erie being held back by the Niagara escarpment. Consequently the age of the Niagara River is a measure of Post-quadernary time. The rate of recession determined by comparison of a recent survey by Woodward with those of Hall in 1842 and the United States Engineers in 1875 would require seven thousand years for the excavation of the 6 miles of gorge. A number of considerations, however, qualify this estimate, and they are summarized as follows:

“At stages of recession earlier than the present there was a thinner body of limestone to be undermined and removed; there was a deeper exposed body of shale; the water plunged from a greater height; the water was concentrated in a narrower channel; it carried more floating ice; and all these differences tended to make the rate of recession faster. The rate may also have been influenced by variations in the amount of detrital load (a tool of erosion), by variations in the solvent power of the water, and by variations of its volume due to changes of climate or catchment basin. The catchment basin was formerly extended by including part of the area of the ice sheet, but it may have been abridged by the partial diversion of Laurentian drainage to other courses.

“The problem admits of expression in an equation:

$$\text{“Age of gorge} = \frac{\text{Length of gorge}}{\text{Rate of recession of falls}}$$

—	effect of antecedent drainage
—	“ “ thinner limestone
—	“ “ thicker shale
—	“ “ higher fall
—	“ “ narrower cross section
—	“ “ more floating ice
±	“ “ variations of detrital load
±	“ “ chemical changes
±	“ “ changes of river volume.”‡

\* Am. Jour. Sci., III, vol. 31, pp. 284-209, and pl.

† Proceedings, vol. 35, p. 227.

‡ Am. Assoc. Proc., vol. 35, pp. 222, 223.



22. Pohlman advances the opinion that in pre-glacial time a small lake occupied the valley between the Niagara and Corniferous escarpments, and drained northward along the line of the present Niagara gorge as far as the whirlpool, and thence down the now drift-filled valley to St. David's. There appears to have been no great cataract, but three small falls over the ledges of hard beds, and the stream was joined at the whirlpool by a branch from the present lower channel. The channel of the Niagara above the Falls was apparently in part cut by the reversal of this drainage into Lake Erie by some agency of the ice age.

These opinions lead to the conclusion that after the lakes were separated at the close of the glacial period the Niagara River had only to clean out the drift-filled channels of the main pre-glacial stream to the whirlpool and thence of its branch to the present outlet. This explanation of the history of the Niagara gorge would greatly decrease the time estimate, but as the amount of work accomplished by the pre-glacial drainage is not known, no figures can be suggested.\*

23. Clappole discusses the drainage relations of the great lakes, and shows that Chicago would be at their foot rather than head if the elevation at Black Rock, near Buffalo, was 20-odd feet higher, so as to cause the drainage of the lakes to flow through the Chicago River into the Mississippi. It is thought that the channel was cut in its present position owing to a glacial ice dam in the Straits of Mackinaw during the retreat of the glacier, which prevented the westward flow and necessitated the excavation of the present channel.†

24. *Lake Lahontan*.—Russell's long-delayed monograph‡ on Lake Lahontan has at last appeared, and the many matters of interest connected with this great fossil lake are discussed in detail. The various questions of sedimentation, shore phenomena, chemical deposition, etc., are treated at length in their bearing on the history of the lake, the whole forming a most important contribution to geologic science. It is only possible here to give a general résumé of the principal conclusions. The lake filled a compound orographic basin, resulting from the tilting of faulted blocks, and received the drainage from many thousands of square miles of surrounding country, with its mechanical load and matter in solution. Its history is taken up at a time of long aridity, which was followed by a period in which the water covered nearly its maximum area and deposited lacustrine marls and clays exceeding 150 feet in thickness. It then evaporated away, with many minor oscillations, and deposited vast quantities of impure carbonate of lime in a stony form of tufa termed lithoid, while stream channels were carved in the lacustral beds and current-bedded gravels and sands were superimposed on the previously formed beds. Another rise of the lake followed, with the deposition of another lacustral series, and when about half-way to

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\* Am. Assoc. Proc., vol. 35, pp. 221, 222.

† *Ibid.*, pp. 222; American Naturalist, Oct., 1886, vol. 20, pp. 857, *et seq.*

‡ U. S. Geological Survey, Monograph No. 11, p. 298, plates and map.

its former level it appears to have been highly charged with saline matter, which was deposited as a crystalline tufa, of which thinolite is the pseudomorph. This stage was probably closed by a rise of the lake and consequent dilution, and the dentritic tufa was deposited, overlapping the thinolitic and extending up against the lithoid. The rise continued and the lake finally attained its highest level, covering an area of over 8,000 square miles, with a depth at greatest of 886 feet. It then carved the Lahontan terrace, after which it evaporated away, probably to complete dessication, forming terraces at different altitudes and depositing a thin coat of tufa. The present lakes are of recent origin.

25. *Volcanic dust deposits in the West.*—In an examination of some Pliocene sandstones, collected by Peale in Montana and Idaho, G. P. Merrill\* discovered that they are principally composed of particles of volcanic glass and other finely fragmental products of vulcanism. It was soon after found that the sand adhering to fossil bones in the Niobrara, Loup Fork, and Sweetwater regions was of similar composition, and other sandstones of the same character were received from Arizona, Colorado, and from Norton and Phillips County, Kansas, showing the wide distribution of deposits of this kind in the West.

26. Peale, in a letter to Science, describes Montana deposits similar to the Loup Fork beds. The volcanic dust in both instances appears to have been ejected high into the air from some vent and to have fallen directly into the lake, as the fineness of the particles bears no relation to the proximity of the ancient shore.†

27. Todd announces the discovery of beds of volcanic dust in Nebraska, where they are associated with what appear to be ice-floe beds of drift. He considers them to have been deposited during the Quaternary, and probably at one stage of King's Lake Cheyenne.‡

#### SOUTHERN TERTIARY.

The controversy on the order of succession of the Tertiary beds of the Gulf States is still kept up by Meyer, who persists in his theory that the Grand Gulf group is the base of the series, in opposition to many observers.

28. Hilgard, in a letter to Science, severely criticises Meyer for neglecting the previous literature and persistently ignoring well-known facts disproving his theory. He declares, for instance, that the statement, pointedly made and verified innumerable times, that "the sandstone of the Grand Gulf group is found overlying the Vicksburg strata generally along the southern line of the Vicksburg group" is entirely disregarded, although Meyer was often near the outcrops at which this could be plainly seen; and again, that in referring to the re appearance of the Jackson shell bed at one point on the Chickasaw River south of the

\* Am. Jour. Sci., III, 32, pp. 199-204.

† Science, vol. 7, p. 163-165.

‡ *Ibid*, p. 373.

main belt, Meyer entirely overlooks the fact that it is there directly overlain by the very characteristic *Orbitoides* limestone of the Vicksburg group, under which it disappears southward.\*

29. A few months later Langdon describes a section along the Pearl River, observed at very low water, from Jackson to Yazoo City, in which a general southern dip is found, and the Jackson beds underlie the *Orbitoides* limestone, although the exact contact was not observed. Sections are described at St. Stephen's Bluff, Bladen's Springs, near Enterprise, west of Meridian and near Claiborne, confirming the general opinion as to the relations of the Vicksburg, Jackson, and Claiborne beds.†

30. In July Meyer makes another contribution to the question, giving an account of a special visit to the region. Owing to high water in the rivers he was obliged to rely upon exposures in railroad cuts but found the latter very satisfactory. An abstract of his results is as follows: Between Pelahatchee and Brandon the Grand Gulf strata are found for five miles at a higher level than the Marine Tertiary west of it, and which are either nearly horizontal or dip strongly westward. At Brandon the marine strata dip over the grand gulf clays, and at the contact have only a thickness of two feet. He can not find a single instance in which the Grand Gulf may be seen in actual superposition on the Marine Tertiary, but on the contrary finds two localities where strata which can not be distinguished from Grand Gulf may be seen actually overlain by Marine Tertiary, and in one case unconformably.

The Grand Gulf formation is considered to be, at least in greater part, non-marine. A thick and extended marine greensand formation is found in eastern Mississippi, which carries a Claibornian fauna approaching the Jacksonian, and is thought to be parallel to the strata immediately below the claibornian profile.‡

31. Heilpriu reports on Tertiary fossils from several localities in the Gulf States. Some specimens from San Augustine County, Tex., are thought to represent the "Claibornian" horizon, and are from deposits probably in the Jacksonian area. Some specimens from Paducah, Ky., indicate the Lower Eocene; and N. Floridanus and other species from near Gainesville, Florida, confirm his opinion of the broad extent of the southern Nummulitic formation and the relative antiquity of the Florida peninsula.§ The same author has issued the second part of his paper on the west coast of Florida|| in advance of the first; but this incomplete publication can not fairly receive attention in this review.

32. Kost ¶ gives a preliminary account of the geology of Florida, in

\* Science, vol. 7, p. 11.

† Am. Jour. Sci., III, vol. 31, pp. 202-209.

‡ Ibid., vol. 32, pp. 20-25.

§ Philadelphia Acad. Sci. Proc., vol. 37, pp. 57-58.

|| Explorations on the West Coast of Florida and in the Okeechobie Wilderness [etc.], pp. 65-127, imp. 8vo, Philadelphia, 1886.

¶ American Assoc. Proc., vol. 35, p. 231.



which it is stated that the peninsula does not consist of a sand bank deposited upon a coral reef, but of Tertiary and more recent strata continuous with these formations farther north and west.

#### MESOZOIC OF THE EASTERN UNITED STATES.

*Trias.*—Many of the important questions connected with this familiar formation still remain unanswered, but over most of its area several systematic surveys have been in progress for some time, and interesting results may be expected from Davis's investigations in the Connecticut valley, Darton's detailed study of the New Jersey and New York district, and Russell's researches on the Richmond coal field and in the Southern States.

33. During the past year Davis has proposed a hypothesis to account for the general monoclinical structure of the Trias, especially of the east-dipping beds of the Connecticut Valley. He finds in this district that the formation is traversed by numerous faults, mostly with the upthrow on the eastern side and parallel to the belts of crystalline rocks which form the Trias basin, and strike under and across it at a small angle. The Triassic rocks were originally deposited on the smoothed-off upturned edges of these crystalline rocks, and the hypotheses demand that, when the latter yielded to a deep-seated horizontal pressure, the bottom of the basin was deformed and the formation faulted. The mechanism of this process is explained as follows:

When the whole mass was crushed, so as to diminish its measure from east to west, it may be supposed that one of the easiest ways of yielding to the crush was by a little slipping of slab on slab, whereby their inclination should steepen and their horizontal measure decrease. If the crushing were more severe near the surface than at great depths, a shearing force would be introduced, that might, if necessary, throw the slabs over past the vertical, and thus produce reversed dips. As slab slips on slab, the formerly horizontal beveled surface of every one is canted over, so as to dip in one direction at an angle equal to the change of the inclination of the slabs; and the surface of every slab is separated from that of its neighbors by faults with upthrow on the side of the direction of dip. The Triassic cover is not strong enough to bridge across from ridge to ridge of the uneven surface thus produced; its weight is much greater than its strength can bear, and it perforce follows the deformation of its foundation, and thereby acquires a faulted monoclinical attitude. The explanation of the Triassic monoclinical may therefore be included in the following general statement. Wherever unconformable masses are deformed together, the structure given to the lesser relatively superficial mass must depend in great part on the changes in the surface shape of the greater deeper mass below.\*

The principal evidence in favor of this hypothesis is the occurrence of the observed faults and their parallelism with the belts of crystalline rocks which strike across the Triassic areas at a small angle. These

\* American Assoc. Proc., vol. 35, pp. 224-227; Am. Jour. Sci., II, vol. 32, pp. 342-352.



faults are only determinable in the trap sheets of the formation, and it is found that the curvature of these and the overlap of their various outcrops is caused by the slight and varying differences between the range of the fault lines and the strike of the beds.

The discovery of these faults indicate that the thickness of the formation in the Connecticut Valley is very much less than formerly supposed, for the repetition of beds produced by the upthrow of the dislocations is always on the side of the direction of dip, allowing a moderate thickness of strata to cover a broad surface area, and causing frequent outcrops of the edges of the four or five trap sheets.

34. The old notion that all the Triassic traps were intrusive is dying out, largely owing to the work of Davis, who has found that in the Connecticut Valley the greater part of the trap has been poured out in broad sheets as contemporaneous lava flows, and has pointed out the probability that the great masses forming the mountains in New Jersey are of the same character; a conclusion which is reached also by Iddings\* from a study of the columnar structure and microscopic character of one of the sheets near Orange, New Jersey.

The Holyoke trap ranges of the Connecticut Valley have been considered overflows by Hitchcock and Davis, and this opinion is confirmed by Emerson† from a very detailed study in Massachusetts, where he finds the trap to consist of two sheets. Rice‡ gives an account of the relations found in the same ridge where it is crossed by the Farmington River, in Connecticut, and the two sheets and the surface features of the lower flow are exposed.

35. The question of the age of the Trias is as yet certainly known only in a general way. Newberry considers the formation the equivalent of Rhætic beds of Germany from its flora, and states that while its fish remains are mostly peculiar, they are more closely related to the Jura and Cretaceous of the older world than to the Permian, and in the Connecticut Valley represent groups confined to the foreign Jura. He finds also that representatives of the Muschelkalk and Bunter are wanting in the United States, and he considers the Ammonites, etc., of Humboldt County, Nev., and the plants of Abiquiu, New Mexico, and Los Brocos, Sonora, to be Upper Triassic. He points out that since no distinctly marked Jurassic fossils have been found east of the Mississippi, and since the well-marked Jurassic of the Black Hills, Utah, etc., overlies the Trias, the use of the term Jura-Trias seems unwarranted; and he supposes that the Permian proper of Europe, as represented by the Zechstein and cupriferous schists, has not been found in America, and that there is here a break between the Upper Carboniferous and the Trias.§

\* Am. Jour. Sci., III., vol. 31, pp. 321-331 and pl.

† American Assoc. Proc., vol. 35, pp. 233-234.

‡ Am. Jour., Sci., III. vol. 32, pp. 430-433.

§ New York Acad. Sci. Trans., vol. 5, pp. 18-19; Am. Jour. Sci., III vol. 31, p. 154.

36. *Younger Mesozoic*.—The age of the New Jersey clays and marls has been briefly discussed by Cook,\* Whitfield,† and Newberry.‡ The latter considers the marls equivalent to the chalk of Europe and the marine Cretaceous of Colorado. Whitfield sees no reason to “dispute the notion generally held that the lower marl bed of the State is equivalent to ‘No. 4,’ or the Fort Pierre group of the Upper Missouri.” Newberry states his opinion that the Raritan clays are at the horizon of the upper greensand of Europe and the Dakota of the West; an opinion shared by Cook. Whitfield thinks the fauna is in some respects allied to that of the Jura, and is inclined to consider the group the Eastern representative of that formation.

37. McGee, in a paper on the geology of Washington and vicinity, describes the newer Mesozoic, which occupies a wide area in that district and is there called the Potomac formation. The upper part is made up of highly colored clays, with sand and gravel; the lower part is sand and gravel, with intercalations of clay. Stratification is often absent, and the materials are sometimes intermingled. The formation appears “to consist of inosculating deltas of the Potomac and other Atlantic-coast rivers and the littoral deposits into which they merge, laid down along a bay-indented coast upon a highly inclined and irregular sea-bottom, produced by combined depression and seaward tilting of a deeply corrugated surface in late Jurassic or early Cretaceous time.”§ Newberry considers the Potomac formation Neocomian in age.

#### PALEOZOIC OF EASTERN NORTH AMERICA.

38. President Dawson, in his address before the British Association, discussed the origin of the American Paleozoic sediments, and stated his preference for the theory that they were derived from Arctic lands and deposited similarly to the great sand banks of the Atlantic coast. Hull.|| in a letter to Nature, opposes this idea on the ground of the character of the deposits and the inadequacy of the currents, especially if there was no coast to determine their course. He restates his opinion that the sediments were deposited off-shore from a very wide land surface in the region of the present Atlantic Ocean, “toward which the sediments thicken, and opposite to that in which the limestones are most developed.”¶ Dana\*\* and Le Conte†† disagree with Dawson and Hull in considering the Paleozoic land surface to have

\* Branchiopoda and Lamellibranchia of the Raritan Clays and Greensand Marls of New Jersey, by Whitfield, pp. IX-XIII.

† *Ibid.*, pp. XVI-XX.

‡ New York Acad. Sci., Trans., vol. 5, pp. 18-19.

§ District of Columbia, Report of Health Officer for 1885, pp. 19-21, and Am. Jour. Sci., III, vol. 31, pp. 473-474.

|| Canadian Record Science, vol. 2, pp. 201-228, 265-285, and elsewhere.

¶ Vol. 34, p. 496.

\*\* Am. Jour. Sci., III, vol. 32, pp. 407-408.

†† Geol. Magazine, vol. 3, pp. 97-101 and 189-190.

included all or part of the Archean now exposed in New England and southward, and not to have extended any great distance eastward.

39. Shaler describes the geology of the Cobscook Bay district, near Eastport, Maine, where he finds a series including Devonian, Silurian, and perhaps Archean members, intermingled at various horizons with lava flows, intruded sheets and dikes, and at some points with beds of fragmental volcanic rocks, as ash and breccia. The sedimentary rocks are in greater part fine-grained sandstones and dark-colored shales, with occasional thin beds of limestone. The ash beds are found interbedded with fossiliferous strata at several horizons, and one bed, just below a shale tentatively referred to the Hamilton, is 500 feet in thickness. The volcanic activity appears to have been greatest to the northeastward, as the extravasated matter decreases in amount in the opposite direction. The igneous rocks are in greater part felsites and felsite porphyries, but other varieties are found. The entire stratified series, with a very few exceptions, has an easterly dip of from  $20^{\circ}$  to  $60^{\circ}$ , and the beds are much compressed and their fossils contorted. The principal faults range NNE. and SSW., with a subordinate series at right angles, and the dikes generally occur along the fault lines. Provisional names have been applied to the formations, but there is still some doubt about their relation to each other and to other beds along the coast. The basal rocks are crystalline and thought to be Laurentian. Upon them lie what is termed the Campobello group, consisting of about 4,000 feet at least of slaty beds without observed fossils, and probably Cambrian or Siluro-Cambrian in age. They are unconformably overlain by the Cobscook group, which also has a thickness of about 4,000 feet. Its upper part yields a Devonian fauna somewhat resembling that of the Hamilton, and the Lower Helderberg and other Silurian groups are thought to be recognized farther down; but the species are mixed and not always determinable. The uppermost group is the Perry series, which constitutes over 2,000 feet of coarse red sandstones, conglomerates, and reddish shales, apparently Upper Devonian or Subcarboniferous.\*

40. At a meeting of the New Brunswick Natural History Society,† Matthew states that on Frye's Island he has recognized the same succession of Silurian strata as is found on the Mascarine shore of Passamaquoddy Bay, and that the belt of red conglomerate extending from Black's Harbor toward Eastport is Devonian.

41. In a report of studies of parts of northern and western New Brunswick, Bailey describes the distribution, stratigraphy, and structure of the several formations and discusses their horizons. The Carboniferous is represented in its upper part by gray sandstones, grading downward into bright-red conglomerates and shales of the Lower Carboniferous, which also contains great masses of volcanic material, and in some localities beds of limestone and gypsum. The supposed Devonian is rep-

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\* Am. Jour. Sci., III, vol. 32, pp. 35-60.

† Bulletin No. 5, p. 38.



resented by a very limited area yielding plant remains. The Silurian consists in greater part of slate, with thick beds of limestone, approximately Lower Helderberg in age. The members of the Cambrian-Silurian series are mostly slates and sandstones greatly disturbed, and in some places graduating into beds of micaceous schists.\*

42. Messrs. Seely and Brainard describe the geology in the vicinity of Fort Cassin, Vermont, near the shore of Lake Champlain. The district is one of simple monoclinical structure, with gentle dips. The strata are Lower Silurian limestone, some beds of which yielded a fauna of many new species, which are described and figured by Whitfield, who also discusses the horizon of the beds.†

43. Darton, in a paper on the Upper Silurian at Cornwall Station, Orange County, New York, describes an outlier of Lower Helderberg limestone lying upon beds of conglomerates and shales, forming an outlier far distant from the main mass of the formation. The Water-Lime, Pentamerous and Delthyris Shaly are recognized by abundant fauna. The beds are uptilted at a high angle, and the greatest exposed thickness is about 100 feet, the outcrop having a length of about half a mile along a NNE. and SSW. strike.‡ The same writer announces the approximate Niagara age of the fossiliferous limestone associated with the Green Pond Mountain series at Upper Longwood, and in Newfoundland, New Jersey, which had been considered Trenton by Cook.§

44. S. G. Williams gives an account of additional observations upon the westward extension of rocks of Lower Helderberg age in New York. He finds the group, including all above the Water-Lime, to be represented at least as far west as Cayuga Lake by limestones not less than 65 feet in thickness, and carrying an unmistakable fauna. The gypsiferous limestone of Cayuga County holds a mixed Tentaculite and Lower Pentamerous fauna. At the outlet of Skaneateles Lake and at the Oriskany Falls, near Utica, the formation is represented by the Tentaculite limestones, which at the last-named place is overlain by mixed Lower Pentamerous and Delthyris Shaly. From the increasing indistinctness of the divisions, and the predominance of the lower portion of the Lower Helderberg to the westward and of the Salina Group to the eastward, it is concluded that the two groups may have been deposited simultaneously, or at least so in part.|| The same author, in a paper on the Tully limestone of New York, calls attention to its outcrop line and flexures, and gives an account of its fauna, which includes 120 species.¶

45. Pohlman describes a well-hole near Buffalo, New York, in which 1,305 feet of Onondaga strata were pierced, the well ending in soft

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\* Canada Geol. Survey, Report for 1885.

† American Mus. Nat. Hist. Bulletin, vol. 1, pp. 293-348, and pls.

‡ Am. Jour. Sci., III, vol. 31, pp. 209-216.

§ Hunt's Mineral Physiology and Physiography, p. 591.

|| Am. Jour. Sci., III, vol. 31, pp. 139-145.

¶ Am. Assoc. Proc., vol. 35, pp. 213, 214.



shale at its lower part; a fact indicating that the Niagara group must either thin rapidly from its outcrop or increase considerably in dip.\*

46. Wright† gives an account of a salt mine at Piffard, in western New York, where a shaft has been sunk 1,105 feet to beds of salt which aggregate 80 feet in thickness within 200 feet.

Wohlmann finds that Sherwood has overlooked the occurrence of Oriskany in Lycoming County, Pennsylvania, for he has been able to trace it for some miles in an inconspicuous ridge on both sides of the great anticlinal, and separating the Lower Helderberg and Marcellus, which are shown to come together on the Second Geological Survey map.‡

47. The Clinton group of Ohio is the subject of a memoir by Foerst, and while it is only preliminary to a more extended and detailed report, it describes the fauna and many of the outcrops. The term Clinton is only used provisionally, as the formation is very closely related to the Niagara, and has only been distinguished from the latter by being richly fossiliferous and separated by a few inches of clay or marl. Its fauna does not differ materially from that of the Niagara, and both are limestones of similar character. The so-called Clinton is only from 10 to 15 feet in thickness in western Ohio, but is somewhat greater farther eastward. It is unconformable by erosion to the Cincinnati group, and holds pebbles of the latter often in considerable amount.§

In an economic description of the coal and iron of the Southern Appalachian, Porter|| gives some account of the Clinton group in that district and describes some of its stratigraphic and structural features.

Boyd,¶ in a somewhat similar paper on southwestern Virginia and adjacent parts of Tennessee, describes the geology and gives some detailed information in regard to the structure of that region.

48. In the continuation of their review of Rogers' Geology of the Virginias, the Campbells add some interesting and valuable statements on the structural and stratigraphic relations in western Virginia. The Niagara is stated to consist of alternating beds of conglomerates, hard sandstones and shales, calcareous in greater part in its upper members, and holding occasional beds of impure limestone. The occurrence of the Salina in Virginia is thought to be open to question, but if it exists it is represented by calcareous shales, with occasional limestone beds in Rogers', No. V. The inseparability of the Silurian and Devonian at the base of the Oriskany is urged, as the rocks and fauna of the Lower Helderberg graduate into those of the Oriskany, and a much better line of division is found above the latter, where the Corniferous

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\* Buffalo Soc. Nat. Hist. Bull., vol. 5, pp. 97-98.

† Science, vol. 8, p. 52.

‡ Philadelphia Acad. Sci. Jour., vol. 37, pp. 296-297.

§ Denison University, Bulletin, pp. 65-120, and plates.

|| American Inst. Mining Eng. Trans., 1886.

¶ *Ibid.*

is wanting and the change in rock and fauna abrupt. The Marcellus, Hamilton, and Genesee form a group about 750 feet in thickness, which in its upper part holds fossiliferous limestone beds. The Catskill is a transition series in every respect. The subdivisions of the Subcarboniferous are well characterized the lower division bearing small quantities of coal, and is supposed to have furnished the salt of the Holston valley deposits.\*

49. In describing the coal district in Sullivan County, Pennsylvania, Ashburner† makes some observations on its general stratigraphy, and considers White justified in assigning the whole of Wyoming County east of the Susquehanna to the Catskill formation, but finds the supposed equivalency of some of the conglomerates in the North Mountain region open to question.

50. The same author describes the occurrence of a thin bed of fossiliferous limestone in the anthracite coal measures in Wyoming valley, Pennsylvania. The fossils are reported upon by Heilprin, and are all of a most pronounced Carboniferous type.‡

51. Linn and Linton report on an examination of borings from gas wells in Washington County, Pennsylvania, in which they find evidence of the occurrence of the mountain or silicious limestone, with characteristics similar to those in the outcrops described by Stevenson in the gaps of Laurel Hill and Chestnut Ridge. Its thickness is about 80 feet. It lies about 1,100 feet below the Pittsburgh coal, is 170 feet below the Piedmont sandstone, and is overlain by 30 feet of black shales.§

52. Ashburner reports on the examination of the coal beds in the Pocono formation (No. X), at Tipton Run, Blair County, Pennsylvania. The horizon of the beds is considered unquestionable. The coal is bituminous, and one bed is as much as 3 feet in thickness.|| The same author¶ reports on the progress of the elaborate survey which is now being made of the anthracite coal region, and while little matter of general geologic interest is presented, the report contains much special information upon details of structure, stratigraphy, and progress of the survey in several fields.

53. Lesley discusses the horizon of the Wellersville coal bed and fireclays. The former belong to the barren series, with the exception of a very small patch of outlying Pittsburgh, and are thought to represent the Platt and Price Coleman and Philson beds of Berlin.\*\*

54. In a paper on the geology of the Pittsburgh coal region, the same author describes the coal beds and associated members, and discusses

\* Am. Jour. Sci., III, vol. 31, pp. 193-202.

† Second Geological Survey of Pennsylvania, Annual Report for 1885, pp. 486-490.

‡ *Ibid.*, pp. 437-458; Wyoming Hist. and Geol. Society, Proc., vol. 2, pp. 254-264.

§ *Ibid.*, pp. 222-226.

|| Second Geological Survey of Pennsylvania, Annual Report of Progress for 1885, pp. 250-258.

¶ *Ibid.*, pp. 269-490.

\*\* *Ibid.*, pp. 227-229.

their horizons, equivalency, and former extent. He calls attention to some interesting facts not generally appreciated in regard to the westward thinning of the Paleozoic series. In central Pennsylvania the thickness of the Paleozoic rocks from the top of the Potsdam to the top of the Pottsville conglomerate is 26,000 feet and in central Ohio only 3,500 feet, and there is a similar thinning northward. Between the edge of the Alleghany Mountains, in Huntington County and Pittsburgh, the lower members of the Carboniferous system thin to one-half. In discussing the flexures of the coal district, discrimination is made between the great low rolls and the gentle plications of some of the Western basins. The former are thought to be part of those of the general Appalachian system, but the latter appear to be due to local subsidence at the time of the deposition, and by the shrinkage due to the compacting of the loose mass of organic matter now pressed into coal.\*

55. D'Invilliers† gives a preliminary account of the general re-examination of the Pittsburgh coal region, describing in detail a portion of Alleghany County. He speaks highly of the work of his predecessors, who determined the more general features, but it is now proposed to prepare contour maps of the coal beds, and very detailed work is contemplated.

56. McCalley reports on the study of the Warrior coal field of Alabama, and describes many details of its coal beds, structure, drift cover, soils, topography, etc. The Warrior field is stated to be a broad, shallow, tray-shaped depression, sloping southwesterly under the newer formations, and much flexed and dislocated on its southeastern part. It is principally composed of sandstone, conglomerates, shales, slates, and coal seams, with occasional beds of limestone. The country is plateau where underlain by the conglomerates, and this holds coals which thin southward. It is thought that in the basin district near Tuscaloosa there are 300 feet of coal measures, with nearly fifty seams of coal, aggregating 100 feet in thickness, and varying from a few inches to 14 feet each. Thirty-five are known to be 18 inches or over in thickness and fifteen over 2½ feet. They are thickest in the center of the basin and thin northwestward.‡

57. Hill calls attention to the very exceptional occurrence of coal in the Carboniferous of Colorado. The coal is anthracite, and in very thin beds, probably in the Middle Carboniferous.§

58. Hicks,|| in a paper on the Permian of Nebraska, provisionally applies the term to a group of strata along the valley of Blue River in Gage County. They consist of less than 200 feet of magnesian lime-

\* American Inst. Mining Eng., Trans., 1886.

† Second Geological Survey of Pennsylvania, Annual Report for 1885, pp. 125-221.

‡ Alabama Geol. Survey, Report on Warrior Coal Field, pp. 571-80. 1886.

§ Colorado Sci. Soc., Proc., vol. 2, pp. 25-26.

|| American Naturalist, Oct., 1886, vol. 20, pp. 881-883; Am. Assoc., Proc., vol. 35, pp. 216-217.



stone, quite distinct from the underlying coal-measure shales, and possibly unconformable to them. Of the one hundred and twenty-three coal-measure species in Nebraska, not more than a dozen pass upward into this group. The overlying Dakota group lies on its irregular eroded surface. It is thought that the old maps representing this formation, extending from the Kansas line to the Platte, are erroneous, as on the surface the group only appears to cover Gage and parts of the adjoining counties. Newberry, in discussing this paper, questions the propriety of calling the beds Permian, as their fauna is not characteristic, and expresses the opinion that this formation does not occur in America. Walcott stated that he regards some Arizona beds as good representatives of the Permian.

59. *Cornwall Iron Mines, Pennsylvania.*—So many opinions have been held in regard to the position and origin of the ore beds at these important mines, and the similar ones northward, that the papers on the subject which have appeared during the past year have more than usual general interest. One is Willis's long-delayed report of studies made in 1881 for the Tenth Census,\* and the other is a very detailed report by Lesley and d'Invilliers† of work in 1885. These writers agree in considering the deposits entirely independent of the Mesozoic and to have been derived from calcareous shales or limestone into which they are found to graduate. Lesley and d'Invilliers, from a careful study of the structural relations, consider the horizon of the ore to be approximately Trenton and apply the term "Cornwall Slates" to the extension of the unaltered shales along the Trias border. Willis suggests the possibility of the ore representing the Upper Primal and that the limestones are above the ore; their apparent subordination at some points being due to cross faults, of which other evidence was found. Lesley thinks that the ore body is separated from the adjoining Trias by a fault, but Willis and d'Invilliers do not share this opinion, considering the overlap to be that of a simple shore line. Lesley and d'Invilliers describe many details of the trap associated with the ore, and consider its curved outcrop due to branching dikes and intrusions along a slightly crumpled monoclinel.

#### CAMBRIAN AND TACONIC.

The Taconic controversy is now rapidly approaching its end, and if discoveries of fossils and determinations of structural relations continue as in the past year or two, it will soon be satisfactorily terminated.

The manner in which much of the literature on the subject has been received indicates that in this, as well as other questions of its class, nothing will be convincing to most geologists but the results of careful

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\* Report on Mining Industries, pp. 223-234.

† Second Geological Survey of Pennsylvania, Annual Report for 1885, pp. 461-470, and pls., and by d'Invilliers, Am. Inst. Mining Eng., Trans., 1886.



systematic field-work—something the Taconic district had never received up to within a few years past.

60. In regard to the use of the term Taconic, opinions will always differ, whatever the issue. No one now questions the fact that Emmons was the first to definitely call attention to the occurrence of a primordial series in America, and notwithstanding the great opposition, much of which was prejudiced, persisted in his views. It seems unfortunate that his typical Taconic proves to be in greater part Lower Silurian; but he also applied the term to other areas by lithologic analogy, and as these are now found to be Cambrian, some will always be in favor of giving the name Taconic to this series as an honor to the geologist who first recognized the primordial in America. In the literature of the past year Winchell\* is in favor of this. Walcott uses the term for his Middle Cambrian, but Dana† is opposed to this on the grounds that Emmons's typical Taconic is not primordial, and that his application of the term to others arose from the very faulty supposition of identity of age in rocks of lithologic similarity.

61. Walcott announced before the American Association his discovery of a Middle Cambrian or Georgian fauna in limestone in the slate, near Middle Granville, Washington County, New York. These slates aggregate 10,000 feet in thickness. The red slates of the same district are found to be of Hudson River age.‡

62. Dwight calls attention to the occurrence of Trenton fossils in metamorphic limestone of Emmons's original Taconic, at Canaan, New York,§ and Bishop finds similar exposures at approximately the same horizon farther north, near Chatham and Kent, in Columbia County.|| Dana discusses Dwight's discovery in its bearings on the Taconic question, and shows that the limestone is unquestionably part of Emmons's original Taconic, and that the same strata comes up on the other side of the synclinal as the Stockbridge limestone, and is traceable for many miles northward into Vermont. It is conformably overlain by slates unquestionably Hudson River in age, which at some points have yielded characteristic graptolites to Hall. The question of overthrust in the Taconic district is discussed, and it is shown that this could be easily detected if it existed to a sufficient extent to invert the order of succession, as in the Scottish Highlands. Some slightly overturned flexures occur, and most of the faults are overthrust to the eastward; but these are purely local results and do not affect the general problem. The absence of fossils and increasingly crystalline condition of the rocks eastward is thought to be due to an increased amount of metamorphism in that direction.¶

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\* Science, vol. 7, p. 34.

† Am. Jour. Sci., III, vol. 31, pp. 242-243.

‡ Amer. Assoc., Proc., vol. 35, p. 220-221.

§ Am. Jour. Sci., III, vol. 31, pp. 243-256.

|| *Ibid.*, vol. 32, pp. 438-441.

¶ *Ibid.*, vol. 31, 241-248; vol. 32, pp. 236-239.

63. In his second contribution to the study of the Cambrian faunas Walcott discusses the classification of this series in the light of present knowledge of its stratigraphy and fauna. The Cambrian is shown to be as distinctly a system as the Silurian, Devonian, and others, being represented by over 18,000 feet of strata, with ninety-two genera and three hundred and ninety-three species, of which very few pass upward into the Ordovician, or so-called Lower Silurian. Its subdivisions into upper, middle, and lower is shown to be required, and although the middle is transitional in fauna, it presents well-marked characteristics. A detailed description is given of the sections of Georgia, Vermont, and at Eureka, and in the highland ranges, Nevada, where the faunal and stratigraphic distinctions between the Middle or Georgian and the Upper or Potsdam is distinctly exposed. It is also shown that the Upper Cambrian or Potsdam of the Mississippi Valley is faunally distinct from the Middle Cambrian, which, however, is not recognized in this district. The Lower Cambrian is only found east of eastern Massachusetts, and is represented by the faunally characteristic series of St. Johns and Braintree, as there appears to have been a barrier up to the end of the Lower Cambrian, preventing its extension to the eastward. The following table is given as a classification of North American Cambrian rocks:

Upper Cambrian	{	Lower Calciferous	{ Lower portion of the Calciferous formation of New York and Canada; Lower Magnesian of Wisconsin, Missouri, etc.
		Potsdam, Knox, Tonto.	{ Potsdam of New York, Canada, Wisconsin, Texas, Wyoming, Montana, and Nevada; Tonto of Arizona; Knox Shales of Tennessee, Georgia, and Alabama. The Alabama section may extend down into the Middle Cambrian.
Middle Cambrian	{	Georgia, L'Anse au Loup Prospect.	{ Georgia formation of Vermont, Canada, and New York; limestone of L'Anse au Loup, Labrador; lower part of Cambrian section of Eureka and Highland Range, Nevada; upper portion of Wasatch Cambrian section, Utah.
Lower Cambrian	{	St. John, Braintree, Newfoundland, Wasatch, Tennessee (?).	{ Paradoxides beds of Braintree, Mass.; St. John, N. B.; St. John's area of Newfoundland; Lower portion of Wasatch section, Utah. The Ocoee conglomerate and slates of East Tennessee are somewhat doubtfully included.

The Grand Cañon, Chuar, Llano, and Keweenaw series are considered pre-Cambrian on account of unconformity with the unmistakable Cambrian and their inconspicuous faunas. They are termed the Keweenaw group, and the interval between them and the Upper Cambrian is thought to be a hiatus equal to the Middle and Lower Cambrian; the Keweenaw not being directly overlain by the two latter as far as known.\*

64. In continuing his investigations in the vicinity of Poughkeepsie, New York, Dwight has discovered an outcrop of fossiliferous Potsdam

\* U. S. Geol. Survey Bulletin (No. 30), vol. 4, pp. 727-1095; and Am. Jour. Sci., III, vol. 32, pp. 138-157.

limestone, brought up by a fault against the Hudson River slates. The thickness exposed is about 300 feet. He suggested that the fault may be related to the great dislocation of Logan, as it ranges NNE. and SSW., and has been traced for some distance.\*

65. The stratigraphy of the Cambrian of the Northwest is discussed by Winchell from recent observations in the valley of Minnesota. The following table represents his conclusions in regard to the relations of the several sandstones and limestones constituting the Cambrian of Minnesota and Wisconsin:

St. Peter's sandstone.

Shakopee limestone.

New Richmond beds

Main body of limestone.

St. Croix	{	Jordan sandstone (Potsdam?).
		St. Lawrence limestone.
		Shales.
		Dresbad sandstone (Potsdam?).

Shales.

Hinckley sandrock (Potsdam?).

Red shales and red sandrock, passing into the Cuprififerous? (Potsdam?).†

66. Dawson, in his report on the Canadian Rocky Mountains, describes the Cambrian of that district. The rocks consist in the main of 11,000 feet or more of quartzites and quartzitic shales passing into argillites, and including occasional beds of limestone, conglomerate, and lava flows. A few Middle Cambrian fossils were found in its upper part, but with this exception the series is closely similar to the quartzites and argillites of the Wasatch and the Chuar and Grand Cañon group of Arizona.‡

#### ARCHEAN AND METAMORPHIC.

The crystalline metamorphic rocks of the United States have been subjects of controversy almost from the first; and although much has been written about them, they have received systematic study at comparatively few localities. In the Appalachian belt there have been those who considered the rocks of some areas to be Cambrian, Silurian, and Devonian in age, the evidence for which from its own character and the recent revelations of the possibilities of paramorphism and metamorphism seems almost incontrovertible; while on the other hand many geologists hold, at least tentatively, that all metamorphic crystallines of considerable areal extent are Archean. In the studies of the past year some of the areas thought to be post-Archean metamorphics are found to be shore lines of Cambrian formations, and consequently pre-Cambrian; while Becker, in California, finds as a result of careful detailed

\* Am. Jour. Sci., III, vol. 31, pp. 125-133.

† Fourteenth Annual Report of the Minn. Geol. Survey, pp. 325-337,

‡ Canada Geological Survey, Report for 1885, B.



studies that some of the crystalline rocks of the coast ranges are altered sandstone of Cretaceous age.\* Dale gives other instances of the metamorphism of the Carboniferous of Rhode Island to gneisses and mica schists.† Emerson, in a paper before the American Association, discusses in detail the relations of the Helderberg limestone and the crystalline condition of overlying as well as of underlying rocks in the Connecticut Valley;‡ and the studies of Van Hise on the enlargement of mineral grains suggests an easily understood explanation of the formation of many of the crystalline rocks of post-Archean age. With all this evidence in view, it now seems probable that the whole controversy about our metamorphics will end in finding that, while the greater mass of them belong to the Archean and its subdivision, there are areas of considerable size which will prove much younger.

There are now in progress three systematic surveys of the crystalline rocks. Pumpelly in the Appalachian belt, Irving in the Great Lake district of the Northwest, and Britton in the New Jersey Highlands. During the past year the two latter have published preliminary reports, Irving for 1883 and Britton for 1885.

67. The principal features of Irving's reports are accounts of a re-examination of the typical Huronian, studies of a number of series which are correlated with the Huronian, and a discussion of equivalency. The typical Huronian is found to consist primarily of quartzite, with occasional beds of graywacke, limestone with chert, and numerous eruptive greenstones, the whole being very gently flexed and unconformable to the older gneisses. With this formation are correlated the Marquette and Menominee, and the Penokee-Gogebie iron-bearing series, the schists and quartzites of the Upper Wisconsin Valley, the slate-belt of the St. Louis and Minnesota Rivers, the quartzites of Cippewa and Barren Counties, Wisconsin, the schists of Black River Valley, the Baraboo quartzites, and those of southern Minnesota and southeastern Dakota, and the Animikie series. The folded schists north and east of Lake Superior are thought to be equivalent to at least the latter.§

68. Bell, in a report on the Hudson's Strait and Bay, describes the crystalline rocks of that district, and states that the schistose members classed as Huronian are either interstratified with the massive beds of the Laurentian system, or conformable to them. The quartzites of the typical Huronian district do not extend far to the north and west, and the schistose series includes, besides a great variety of crystalline schists, more or less massive diorites, argillaceous and dioritic slate, conglomerates, granites, syenites, schistose and jaspery iron ores, limestones or dolomites, and imperfect gneisses. As far as observed, they are much more abundant in the region between the Great Lakes and Hudson's

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\* *Am. Jour. Sci.*, III, vol. 31, pp. 348-357.

† *Canadian Inst., Proc.*, vol. 3, pp. 18-22.

‡ *Proceedings*, Vol. 35, pp. 233.

§ *U. S. Geol. Survey*, 5th Annual Report, pp. 175-282.



Bay than in the Labrador peninsula or north of Hudson's Strait. The same author, in a paper on the mineral resources of the Hudson's Bay Territory, states that on the eastern shore of the bay there occurs a series of sedimentary rocks apparently identical with the Animikie and Nipigon groups. On the western and northwestern shores there are altered rocks resembling the gold bearing series of Nova Scotia, some similar to the Huronian of Lake Huron, and others like the crystalline series near Cherbourg, Quebec. Between the Laurentian nucleus and the Rocky Mountains there is a great basin of Silurian, Devonian, Cretaceous, and Tertiary rocks, which give place northward to limestones, probably of Nipigon age. On the shores of the Arctic Ocean similar limestones, associated with traps, are the prevailing rocks between Mackenzie and Coppermine Rivers, and the copper-bearing rocks of the latter region appear to correspond with those of the Lake Superior district.\*

69. Willis, in a report on a trip to the Upper Mississippi and Vermillion Lake, Minnesota, describes some structural relations of the Vermillion Lake iron-bearing series, the supposed northern equivalent of those of Marquette. The beds are all vertical, and pressed into close folds with exceedingly intricate relations. The iron-bearing bed is of jasper, holding non-magnetic specular ore, and is associated with semi-crystalline schistose rocks and a bed of quartzite containing grains of magnetite. The Vermillion and Two River ranges are thought to be anticlinal ridges, eroded down to the chloritic schists. Some of the structural features are very curious, and the relations under one swampy area were worked out by tracing the magnetite-bearing quartzite with the magnetic needle.†

70. Britton's report (already referred to) is a preliminary account of the continuation of Smock's studies of the Highland Archean for the New Jersey Geological Survey. Smock's discovery that the crystalline rocks could be divided into "massive" and "bedded" was taken up, and the areal and structural relations of each worked out for a portion of the district. The massive and underlying rocks consist in the main of quartz, syenites, granulites, and hornblendic granulites, and graduate into the stratified rocks, which are gneisses, hornblendic schists, etc., but all are considered equivalent to the Laurentian in age. The structural relations are not particularly complicated so far as determined, and the eastern side of the Highlands appears to have been more overturned than the western.‡

71. Farther northward, in the Highlands in New York, Ruttman gives an account of a detailed study of the Tillie Foster magnetite deposit.

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\* Canada, Geol. Survey, Report for 1885, DD., and Am. Inst. Mining Engs., Trans., 1886.

† Tenth Census, Report on Mining Industries, pp. 457-467.

‡ Geological Survey of New Jersey, Annual Report of the State Geologist for 1885, pp. 36-55.

The ore is found in a bed unquestionably interstratified with the crystalline rocks, and presents some evidence of having been originally in granular form and sorted by shore action, as suggested by Julien.\*

72. In the midst of the Adirondacks, at Lower Saranac Lake, Britton notes the occurrence of a series of schistose gneisses with micaceous and hornblendic schists holding abundant quartz veins, and dipping 45 degrees north, and Julien calls attention in this connection to the similar series, bordering the Adirondacks, especially on their eastern side.†

73. In a description of the Wallbridge magnetite mine in Canada, Chapman discusses the Archean rocks of that district, and recognizes four divisions, rather than the three proposed by Vennor. Two of the series are thought to be volcanic, the others metamorphic, and it is thought that the syenites should be separated from the lower stratified gneisses.‡

74. The crystalline rocks extending southward from Westchester County, N. Y., have received some attention in the literature of the past year. At a meeting of the New York Academy of Science, Newberry states his opinion that they are of Archean age; and Martin, in calling attention to their great difference from the Highland rocks, and their more hydrous condition, suggests that it may be due to a long submergence at the bottom of the Trias basin. Britton states that at Washington the series contains less feldspar and generally more mica than in the Highlands.§

75. Britton presents an additional note on the geology of Staten Island. From the discovery of partially altered amphibole in the serpentine, he is of opinion that the latter has been derived from hornblendic or tremolitic strata, which have been found to a limited extent on the island, and from magnesian limestone. He states that the stratification of the rocks is unquestionable, and gives a number of dips. It is thought that the serpentine does not form an anticlinal, as before described, but probably a geosynclinal. As the serpentine of Hoboken, Staten Island, and New York lie along the strike, it is suggested that they may occupy a belt in the gneisses, and that their outcrops and those of the limestones of New York Island may be due to pitch or to cross faults.||

76. Frazer, in a sketch of the geology of York County, Pennsylvania, summarizes his views on the crystalline rocks of that district. None of the rocks are thought to be Laurentian or Norian, unless, perhaps, in a portion of the South Mountain. The lowest horizon appears to be equivalent to the horizon of the Huronian, which is supposed to cover most of the areas, and of which at least 14,000 feet is exposed in the

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\* American Inst. Mining Engs., Trans., 1886.

† New York Acad. Sci., Trans., vol. 5, p. 72.

‡ Canada Royal Society, Trans., vol. 3, sec. IV, pp. 23-26.

§ New York Acad. Sci., Trans., vol. 5, pp. 19, 20.

|| Nat. Hist. Soc. of Staten Island, Trans., Oct., 1886.

Susquehanna anticlinal. These lower rocks are more perfectly crystalline and contain a greater proportion of muscovite and feldspar than the upper series into which they graduate, and which are magnesian, less crystalline, and possibly of Paleozoic age. The quartzites of Chikis, Chester Valley, etc., are thought to be Potsdam from their unconformity to the underlying schists.\*

#### PACIFIC COAST.

77. Two systematic geologic surveys are now in progress in the State of California, one by Becker, at present in the southern part, and the other by Diller, on the volcanic geology. Some of Becker's results are given in a paper which is referred to at length under "Metamorphism and Paramorphism," and announces the Neocomian age of a portion of the crystalline schists of the Coast ranges.

Diller makes a preliminary report of progress of work in the northern part of the State, which throws much light upon its geologic history. It is found that the Carboniferous limestones are quite widely distributed and probably embrace all those of the metamorphic rocks. Gilbert's suggestion that the Sierra Nevada has the basin-range structure is verified, and three westward-sloping blocks are recognized. The age of the auriferous slates is considered doubtful; while one portion of them is certainly Mesozoic, another portion is apparently older than the Carboniferous limestone, and is, perhaps, altogether pre Carboniferous. The great displacements forming the Sierra Nevada appear to have begun about the close of the Tertiary, and may still be in progress. The distribution and relations of the Chico group indicate that during the Chico epoch much of what is now the Coast Range region in northern California was an island separated from the continental mass to which the Sierra belonged by a strait which has since been filled by Lassen Peak lavas to form a portion of the present Cascade Range.†

78. Le Conte discusses the time of the elevation of the Sierra Nevada from the evidence afforded by the river beds in middle California. In that district the lava flows at the end of the Tertiary were only of sufficient thickness to fill up the river channels and cause them to shift their courses to the divides. Previous to this the base-level of erosion had been almost attained, and since the lava flows there has been a great uplift, which has caused the rivers to cut the deep, narrow gorges in which they now run. This idea of post-Tertiary uplift in the Sierra Nevada is interesting in connection with Dutton's study in the plateau country, where the elevation took place approximately at the same time, and was similarly attended by faulting and great lava flows. According to studies of Gilbert and Russell on the faults of the Great Basin, uplift in that region appears to have begun in the beginning of the Quater-

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\* Am. Phil. Soc., Trans., vol 23, pp. 391-410, and map.

† U. S. Geol. Survey, Bulletin No. 33 (vol. 5, pp. 369-387).



nary, and was probably contemporaneous with that of the Sierra Nevada. It is thought that the great lava flow of the Northwest commenced at the beginning of the Pliocene, as it lies upon the eroded edges of the Miocene, and must have continued almost to the present time, the greatest flows being as late as the end of the Pliocene.\*

79. Willis reports on his studies for the Northern Transcontinental Survey of the coal measures on the western slope of the Cascade Mountains, in Washington Territory. While the report is in greater part of economic interest only, some general statements are made which form an important contribution to the knowledge of the geology of this district. The coal measures are in sandstones and carbonaceous shales of Laramie age which aggregate 13,000 feet in thickness. The workable beds are seventeen in number, mostly in the lower 3,000 feet of the measures. The quality varies from poor lignite to coking coal in proportion to the mechanical disturbance of the beds. It is locally anthracitic in the vicinity of intrusive dikes. The formation is found to be a brackish water deposit, and by the uplift forming the Cascade Range they were flexed over axes having a general north and south trend. Erosion, volcanic overflow, and drift have obscured the limits of the formation, and it is now only recognized in detached areas. The following table summarizes the conclusions in regard to the equivalency of the several formations flanking the Cascade Mountains: †

West side.	East side.
<ol style="list-style-type: none"> <li>1. Widespread glacial drift.</li> <li>2. Tertiary volcanic rocks.</li> <li>3. Lignites and bituminous coal measures, characterized by angiospermous leaf impressions throughout the entire thickness of 13,000 feet or more.</li> <li>4. Cretaceous strata and conglomerate of the Skookumchuck.</li> <li>5. Serpentine or chlorite schists associated with limestones and resting on granite; common to both sides of the range.</li> </ol>	<ol style="list-style-type: none"> <li>1. Limited glacial drift; lake beds of the Yakima and Columbia Rivers.</li> <li>2. Tertiary volcanic rocks.</li> <li>3. Coal measures of limited extent, 1,000 feet, more or less, in thickness, and coarse sandstone, and thin conglomerate beds, 7,000 to 8,000 feet.</li> <li>4. Conglomerates, 300 to 400 feet.</li> </ol>

Russell, in a very interesting and finely illustrated paper on the existing glaciers of the United States, describes with some detail his own studies of those near Mono Lake, California. Nine glaciers are found in the southern rim of that basin, and a number of others occur on the opposite side of Sierra Nevada, all being between latitude  $36^{\circ} 30'$  and  $38^{\circ}$  north, at an altitude of approximately 11,500 feet. They occur in amphitheatres on the northern side of elevated peaks, and are quite small, the largest, on Mount Lyell, being nearly a mile in length, and a little more than a mile in width. The ice is ribboned in structures, has dirt bands, crevasses, moraines, and other features found in larger glaciers. Their former wide extent is indicated by great moraines and

\* Am. Jour. Sci., III, vol. 32, pp. 167-181.

† Tenth Census Report on Mining Industries, pp. 759-781.



glaciation. An account is given of glaciers on Mounts Shasta, Tacoma, etc., quoted from various observers.\*

### ROCKY MOUNTAINS, ETC.

81. G. M. Dawson, in a paper on a portion of the Canadian Rocky Mountains, gives a description of the relation of the various ranges and the geologic relations and structure along some of the routes across them. It is found that the lowest rocks consist of over 11,000 feet of quartzites, slates, and shales, with occasional beds of limestone and lava flows, and present scanty fossil evidence that they are of Middle Cambrian age in the upper part, but otherwise similar to the quartzites and schists of the Wasatch Mountains of Utah, and the Chuar and Grand Cañon groups of Arizona. Overlying these unconformably is a limestone series of Devonian and Carboniferous age, which occasionally holds quartzites, and may prove in the westernmost parts of the range to pass down into Silurian or Cambrio-Silurian. Triassic or Permo-Triassic red sandstones with traps appear in some places near the forty-ninth parallel, and are overlain by 7,000 feet of shales and sandstones, with coal-beds, which bear a characteristic early Cretaceous or Cretaceo-Jurassic flora, which have been named the Kootanie series. Overlying them, generally with slight unconformity, lie remnants of Middle and Upper Cretaceous, with coal-beds and trap-sheets. The following table is given of the beds above the Kootanie series :

Rocky Mountains.		Feet.	Foot-hills and plains.	Feet.
Laramie	{		Porcupine Hill beds .....	2,500
	St. Mary River beds (base) .....	Not known..	Willow Creek beds .....	450
	Fox Hills and Pierre .....	do .....	St. Mary River beds .....	2,800
	Belly River Series .....	do .....	Fox Hill and Pierre .....	830
	Benton and (Niobrara?) .....	1,400	Belly River Series .....	910
Cretaceous	Volcanic rocks (greatest thickness) ..	2,200	"Lower Dark Shales" .....	800
	Dakota and upper part of Kootanie Series to coal-bearing horizon .....	2,750		
	Lower part of Kootanie Series .....	7,000		
		13,350		8,290

The great mountain-building uplift was in the early Tertiary, and the beds were then thrown into SSE. and NNE. folds, often close and overturned in what is now the mountain district; an eastern belt about 50 miles in width forming the foot-hills, being less contorted, and preserving the younger beds.†

82. In the same report an account is given of the Bow River Valley beds of Kootanie anthracite,‡ and they are also described by Merritt

\* U. S. Geol. Survey, Fifth Annual Report, pp. 303-355, and pls.

† Canada Geol. Survey. Annual Report for 1885, B, and abstract in Can. Record Sci., vol. 3, pp. 285-301.

‡ *Ibid*, pp. 126-127.

in the Quarterly Journal of the Geological Society.\* The coal-beds lie in an overturned synclinal in the Subcarboniferous, on the Devonian limestone. The coal contains about 81 per cent of fixed carbon, and there are several workable beds.

83. Sir J. William Dawson, in a memoir on the Mesozoic floras of the Rocky Mountain district of Canada, discusses the occurrence of plant remains in general, and describes the three new horizons recognized. First, the Kootanie series, supposed to be the representative of the Neocomian, or at least not newer than the Shasta group of the United States, and the lower sandstone shales of the Queen Charlotte Islands, which is regarded as similar to the cycad beds of Maryland. Second, the Mill Creek beds, corresponding closely with the Dakota group, and separated from the Kootanie by a considerable thickness of strata. Above this is a third sub-flora, that of the Belly River series at the base of the Fort Pierre group. This series, though separated from the Laramie proper by the marine beds of the Pierre and Fox Hill groups, an interval of 1,700 feet, introduces the Laramie or Darien flora. The Laramie flora is found to be divisible into two sub-floras, an older, allied to that of the Belly River series, and a newer, identical with that of the Souris River, which appears to agree with the Fort Union group of the United States. The following table is given, showing the equivalency of these series:†

*Successive Floras and Sub-Floras of the Cretaceous of Canada, in descending order.*

Periods.	Floras and sub-floras.	References.
Transition Eocene to Cretaceous.	Upper Laramie or Porcupine Hill	Platanus beds of Souris River and Calgary. Report Geological Survey of Canada for 1879 and Memoir of 1885.
	{ Middle Laramie or Willow Creek beds.	
	{ Lower Laramie or St. Mary River.	Lemna and Pistia beds of bad lands of 49th Parallel, Red Deer River, etc., with lignites. Report 49th Parallel and Memoir of 1885.
Upper Cretaceous (Danian and Senonian).	{ Fox Hill Series .....	Marine.
	{ Fort Pierre Series .....	Marine.
	{ Belly River .....	Sequoia and Brasenja beds of South Saskatchewan, Belly River, etc., with lignites. Memoir of 1885.
	{ Coal measures of Nanaimo, British Columbia, probably here.	Memoir of 1883. Many dicotyledons, palms, etc.
	{ Dunnegan Series of Pease River.	Memoir of 1883. Many dicotyledons, cycads, etc.
Middle Cretaceous (Turonian and Cenomanian).	{ Mill Creek beds of Rocky Mountains.	Dicotyledenous leaves, similar to Dakota group of the United States. Memoir of 1885.
	{ Suskwa River beds and Queen Charlotte Island Coal Series.	Cycads, palms, a few dicotyledons. Report Geological Survey; Memoir of 1885.
Lower Cretaceous (Neocomian, etc.).	{ Intermediate beds of Rocky Mountains.	
	{ Kootanie Series of Rocky Mountains.	Cycads, pines, and ferns. Memoir of 1885.

\* 2. Jour. Geolog. Soc., Vol. 42, pp. 560-564.

† Canada Royal Society Trans., vol. 3, Part IV, pp. 1-22, and Canadian Record of Science, vol. 2, pp. 1-9.

84. Newberry, in a paper on the Cretaceous flora of North America,\* gives the following table which summarizes his views of the relation of the different local floræ:

Canada.	Pacific coast.	Interior.	Atlantic coast.	Greenland.	Europe.
	Carbonado, Washington Territory.	Upper Laramie.	Eocene .....	Eocene (marine).	Eocene.
St. Mary's .....	Vancouver's Island.	Lower Laramie.	.....	.....	Faxoe beds Maestricht.
Peace River.....	Chico, California.	Colorado (marine).	New Jersey marls (marine).	Patoot.....	Chalk.
Mill Creek.....	Shasta, California.	Dakota .....	Raritan.....	Atane .....	Upper Greensand.
Queen Charlotte.	Shasta, California.	.....	Potomac.....	Kome.....	Neocomian.
Kootanie .....	.....	.....	.....	.....	Wealden.

85. In the long-delayed Census report on Mining Industries there are several papers on the coal-beds of the Northwest, the results of the studies of Eldridge, Davis, and Willis for the Northern Transcontinental Survey under the direction of Pumpelly. Willis' report is referred to under another heading. Eldridge† describes in great detail the Montana coal-beds and their associated strata, and Davis reports on the more general geologic relations of the district. The area studied is included in a triangle 120 to 140 miles on a side in south-central Montana, including the Bridger, Big, and Little Belt, Highwood, and Main ranges. The rock series extends conformably from the Lower Cambrian to the Upper Cretaceous, and is from 30,000 to 35,000 feet in maximum thickness. The Cambrian schists are from 10,000 to 15,000 feet thick, but in some parts of the area are very much less and possibly absent. These schists are capped by a persistent layer of quartzite, and a limestone with Potsdam fauna. Overlying this, and separated by a small interval of shales, there are 3,000 odd feet of Lower Carboniferous limestones, generally overlain by a hard quartzite. Then there are 15,000 feet or more of sandstones and shales of the Mesozoic in which the occurrence of the Trias red beds is doubtful. Jurassic fossils occur at 600 feet, many Cretaceous fossils at 3,200 feet, and the Cretaceous coal at 4,400 feet above the Carboniferous limestone, and conformable sandstones, with occasional imperfect plant-remains, extending over 10,000 feet higher. All the post-Carboniferous about the mountains appears to be Mesozoic, excepting Quaternary lake deposits in the upper valleys, and some patches of possibly early Tertiary. Volcanic rocks are found to have been extruded in greater part at the end of the Cretaceous and Tertiary. The workable coal near Bozeman is only 3,700 feet above the Jura fossils, and is far below the Laramie.‡

86. In a paper read before the American Institute of Mining Engineers

\* New York Acad. Sci., Trans., vol. 5, pp. 133-137.

† Tenth Census, report on Mining Industries, pp. 739-757.

‡ *Ibid.*, pp. 697-712.

Comstock describes the geology and vein structure of southwestern Colorado, and discusses at some length the vein stones and ore deposits. The following is an abstract of the statements in regard to the surface geology: The crystalline rocks consist of a quartzite group, and an overlying granite, which are considered post-Archean, and possibly Lower Paleozoic. The Silurian and Devonian are represented at some points by fossiliferous rocks, and may occur over a wide area, of which the age is now in doubt. The Carboniferous is divided into two series, the earlier represented by 1,200 feet or more of argillaceous, arenaceous, and calcareous beds, the latter by over 1,200 feet of red sandstone, with occasional local trachytic inclusions. The Triassic and Jurassic do not cover any considerable area, and may be absent. The Cretaceous appears in force, and the series 1-5 of the Hayden survey are recognized. Coal-beds are found in the upper part of the upper Dakota. The Tertiary is represented by Eocene lake beds, and great lava flows, which appear to be chiefly middle Tertiary. Five series of volcanic eruptions are recognized in the following order: Propylite, andesite, trachyte, crater flows of rhyolite, and finally a few patches of basalt, probably the remnants of Pliocene flows.\*

87. In the Red Mountain districts great geyser deposits are found, and it is supposed that at one time this area experienced geyser action similar to that now active in the Yellowstone Park†

88. Stephens gives a general account of observations made on a trip through the San Juan Mountains. The underlying rocks of the district are a crystalline series, generally overlain by Silurian sandstones, quartzites, etc., and these in turn are often overlain by the Carboniferous. Structural features and outcrops are generally obscured by great masses of volcanic rocks. North of Ouray the country is traversed by numerous faults, often of great magnitude. Two periods of volcanism are recognized, both subsequent to the last uplift. The first is termed the porphyry period, and its viscid lavas are found overflowing the whole district, and intruded between many of the beds, causing great alteration. The second is termed the trachytic period, in which an exceedingly viscid lava appears to have been outpoured upon the mountain tops, but was not sufficiently liquid to flow into the valleys.‡

89. In his report as geologist of Wyoming for 1885, Aughey discusses the geologic position of the hematite deposits of Seminole Mountain. He considers the ore-bearing series to be of approximately Huronian age. It consists of quartzites, and gneissic, hornblendic, and chloritic rocks, with limestones, jasper, and epidotic slates, which form the core of the mountain, and are overlain by Potsdam, Carboniferous and Cretaceous in succession.§

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\* Trans., 1886.

† American Naturalist, vol. 20, pp. 963-965.

‡ New York Acad. Sci., Trans., vol. 5, pp. 121-130.

§ Wyom. Geolog. Rep., pp. 120. 8vo. Laramie, 1886.



90. *Texas*.—The State of Texas has recently published a report by Shumard on the geology along routes traveled by the expedition between Indianola, Texas, and the valley of the Mimbres, New Mexico, in 1855, '56, and of Grayson County, Texas.\* Although issued at this late date, and opinions on some of the broader questions have radically changed, the report contains a great mass of valuable information. Hill, in reviewing it, states that most of the stratigraphic deductions are erroneous, and as shown by Marcou, the sections in the Cretaceous are reversed. The supposed Upper Cretaceous in Grayson County is now known to be Tertiary and the Lower Cretaceous, Upper.†

91. Hill, in a general description of the geologic features of Travis County, Texas, makes the interesting statement that the Cretaceous is in two divisions, differing considerably in fauna and lithology and unconformable to each other, and it is pointed out that the lower division lies altogether below the Dakota horizon.‡ Their areal distribution and structural relations are described, and much local information given.

92. *Mexico*.—Cope, in a report on the coal deposits near Zacuatipan, Hidalgo, Mexico, describes the geologic features of that district. The country is underlain by a silicious limestone said to be Cretaceous and penetrated by numerous trap dikes and sheets. In the depressions in this formation and its volcanic rocks lie regularly stratified horizontal beds of Upper Miocene age, probably equivalent to the Loup Fork series of the United States, and consisting of glass, volcanic ash beds, and the carbonaceous shales, with lignite coal, often of good quality.§

93. *Nebraska*.—In a description of the Lincoln salt basin, Hicks states his opinion that these salt deposits in the Dakota group (especially those of the lower part of the group) || are remnants of old Cretaceous salt marshes, resulting from the evaporation of the sea water during the deposition of the sands.

#### CARTOGRAPHY.

94. During the past year there have appeared two geologic maps of the United States, one by McGee,¶ the other by Hitchcock.\*\* That of the former is left uncolored west of the 112th meridian, together with most of New Mexico, half of Arizona, and with the exception of a portion of Nevada and the Puget Sound district. That of the latter is colored in accordance with the scheme recommended by the International Geologic Congress, and all but the northern part of Idaho and south-

\* A Partial Report on the Geology of Western Texas, by George G. Shumard 1855-1860. pp. 145. 8vo. Austin, 1886.

† Am. Jour. Sci., III, vol. 33, pp. —.

‡ Austin Statesman, Dec. 15, 1886.

§ Am. Phil. Soc., Trans., vol. 23, pp. 146-151.

|| American Assoc., Proc., vol. 35, p. 219.

¶ U. S. Geol. Survey, Fifth Annual Report, pocket, 17" by 28".

\*\* Am. Inst. Mining Engs., Trans., 1886, 17" by 28".

western California are colored. McGee's map is dated 1884, and is not only compiled from published information, but from manuscript maps in some areas. It differs from previous maps in numerous respects. Besides more accurate delineation of boundaries, the crystalline rocks of New York Island and of Westchester County are represented as Silurian; the New England crystallines and those of all the Piedmont and Appalachian belt are colored as Archean, including the semi-crystalline schists of central South Carolina, central and western North Carolina, southeastern Pennsylvania, and parts of New England. The oldest rocks of Texas are referred to the Cambrian, and the Archean area in Missouri are shown surrounded by Cambrian. The southern half of Long Island is represented as Tertiary, and much of the Atlantic coast, especially that of North Carolina, is thus shown. The gypsiferous series of Kansas, Indian Territory, and New Mexico is incorporated with the Cretaceous; the Eocene of Texas is given a great width along the Rio Grande; the cross-timber district of Texas is shown as Quaternary, and a large portion of Dakota and Minnesota is similarly shown.

95. Hitchcock copies McGee's boundaries in districts of which the geology is less open to question. In the Black Hills and eastward the Archean is subdivided into Laurentian and Huronian. Cambrian is represented in southwestern Maine, in central South Carolina, and in west central and in western North Carolina. The underlying rocks are shown as far as possible in Minnesota and Dakota instead of the overlying drift, information for Minnesota having been furnished by Upham. The gypsiferous series of Indian Territory, Texas, and New Mexico is shown as Trias, and the Jura and Trias are separated as far as possible in other parts of the West; much information from Pumphelly, Blake, Willis, Dutton, and Diller is utilized for the far West, but large areas are colored hypothetically. The gold slates of California are represented as Jurassic and Cretaceous metamorphic, but not with approbation. For the Canadian areas in the East and far West much new information has been incorporated.

During the past year there has appeared the report of the International Congress of Geologists, in which an account is given of the results attained towards uniformity in geologic nomenclature and cartography.

#### PETROGRAPHY.

Besides the papers referred to in the following paragraphs, there are several others containing petrographic information of a most interesting character, notably those of Becker on the Cretaceous crystallines of California, and Williams on a district west of Baltimore, both of which are noticed under "Metamorphism and Paramorphism."

96. G. H. Williams describes in detail the petrographic characteristics of the peridotites of the Cortlandt series near Peekskill, New York. Two varieties are found, one containing hornblende and the other py-

roxene. The hornblendic peridotite is dotted with small rounded grains of olivine or serpentine, as in the Schillerspath or bastit of the Hartz Mountains, and for which the name poecilitic (mottled) is proposed. The hornblende is of the variety called basaltic, and contains characteristic specular intrusions. It is not crystalline, but fills spaces of the rock, and often forms masses of some size, the other minerals appearing to have crystallized from it, probably under much pressure. The olivine has interesting inclusions, and at its contact with the feldspar it is always separated by a zone of square grains of pyroxene and tufts of radiated actinolite. The pyroxene generally appears to be hypersthene. Feldspar is never an important constituent. This rock grades into augite-peridotite by transition, the hornblende giving place to augite. The rocks are mostly massive, but are sometimes somewhat schistose, and appear under the microscope to have been subjected to much pressure. All the basic members of the Cortlandt series are too acid to pass as representative olivine rocks, as the amount of this constituent is small.\*

97. The petrography of the peridotite in the Carboniferous of eastern Kentucky is described by Diller, who finds it to consist in the main of about 40 per cent. of olivine, 30 of secondary serpentine, 8 of pyrope, and 14 of dolomite. The relation of the peridotites to the associated sedentary beds is discussed, and as the latter are indurated, and its fragments occur in the peridotite, it is thought that the latter is undoubtedly intrusive.†

98. Lindgren describes the petrographic features and the relations of the eruptive rocks of south central Montana, as a supplement to Davis' paper (see 85). It is found that the oldest eruptive is a granite with red orthoclase, occurring in dikes in gneiss at the head of Belt Creek, in the Little Belt Mountains. The next period of eruption appears to have been in the Cambrian or the Silurian, and rocks consist of a diabase, sometimes quartzose, with the quartz granopyric in structure. This was succeeded in the Jurassic by acid magmas issuing as flows and dikes of diorite, granites and quartz porphyrites, and latter presenting two varieties, the augitic and the hornblendic. In the Laramie and Tertiary, volcanism was very active and varied. The sequence of eruptions is not worked out, but the andesite flows appear to have commenced late in the Cretaceous or Laramie. The hornblende dacites are found massive in the Little Belt Mountains, as dikes in Laramie in front of the main range, and with andesites in the Laramie conglomerates in the Highwood Mountains. No augite-dacites, and only a few augite-andesites were found. Liparites are found in front of the main range as dikes in Laramie strata. The most recent eruptions appear to have been in the post-Tertiary, probably Pliocene, and consist of trachytes and basalt. The former are nearly all devel-

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\* Am. Jour. Sci., III, vol. 31, pp. 26-41.

† *Ibid.*, vol. 32, pp. 121-125.



oped as augite-trachytes, some of which are very rich in augite. The basalts are in part plagioclastic; another part consist of analcite (nosean) basalts, originally composed of nosean augite and olivine, with the former changed to analcite—generally occurring in dikes, often crowded in great numbers, and apparently older than trachytes.\*

99. Newberry quotes the results of examination by Iddings of some of the igneous rocks from the Lower Silurian and Cretaceous of the Belt Mountains, and consisting of typical augite-andesites, true trachytes and rhyolites.†

100. Becker, in a paper on the Washoe Rocks, discusses Hague and Iddings' criticism on the petrography in his monograph on the Comstock lode. An account is given of a re-examination in the field, the result of which substantially corroborates his previous conclusions that there were two separate eruptions of porphyritic, pyroxenic, and plagioclase rocks, presenting sufficient differences to be separated into diabase and andesite. Additional reasons were also found for maintaining the existence of diabase, and for dividing the pyroxene andesite into two distinct outflows separated by a long interval of time, contrary to Hague and Iddings' opinion that the rocks constitute substantially a single Tertiary eruption. The structural features and petrography of the rocks in question are discussed in detail, and while somewhat slight corrections are made to his previous statements, he finds Hague and Iddings' hypothesis of progressive crystallization inapplicable in explanation of the differentiation of the several members of the Comstock district.‡

101. In a paper on columnar structure in the Mesozoic igneous rocks of New Jersey, Iddings describes the petrography of the diabase near Orange, New Jersey. It is found that it differs in some respects from most of the similar igneous rocks in that part of the country. "Generally the microstructure of these rocks is holocrystalline, formed of lath-shaped, basic feldspar, irregular crystals and grains of augite, grains of iron oxide, and considerable green serpentine or chlorite, which is disseminated through the mass, and is evidently the alteration product of a fourth primary constituent." The rock from the quarry described "is not holocrystalline, but contains a variable amount of glass base, which is more or less globulitic, with augite microlites having opaque grains attached, besides larger aggregations of magnetite grains. There is a comparatively small amount of serpentine in patches, the larger of which still contain fragments of olivine at their centers, the former mineral from which the serpentine has been derived. In some places the glass base has been colored green, though still isotropic, while in others it has been devitrified through decomposing agents. The rock with the least glass and coarsest grain of crystallization is from the large columns" near the base of the trap sheet, while that near the same

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\* Tenth Census: Report on Mining Industries, pp. 719-737.

† New York Acad. Sci., Trans., vol. 5, pp. 247-270.

‡ California Acad. Sci., Bulletin No. 6.



level but from "small columns shows nearly the same size of crystals with more glass base." Higher up in the sheet the rock in medium-sized columns "has somewhat smaller feldspar crystals and more glass base, in places brown and globulitic, with fern-like groups of magnetite crystals. Midway up the cliff the rock shows still more globulitic and microlitic glass, and that from 10 feet below the present upper surface has smaller crystals and rather more glass base. The variations from bottom to top of the lava are slight but distinctly noticeable, and indicate that the cooling which caused the consolidation of the mass was more rapid at the top than at the bottom, which corresponds with the subsequent conditions deemed necessary to produce the different systems of columnar cracking."\*

102. McCormick discusses the nature of concretions in crystalline rocks and describes in detail those in the granite in Craftsbury, Vermont. From a study of the literature of the subject two classes of inclusions are recognized; the first are ovoid in structure, seldom sharply defined, and often include nodules. They are believed to be contemporaneous with the solidification of the enclosing rock mass. The second class are generally angular and very dissimilar from the matrix. In the granite of Craftsbury the inclusions consist of spheroidal nodules of biotite from one-half to two inches in diameter and often four inches in length, in some cases much flattened and crumpled. Microscopic examination shows the mica to be in concentric layers with scattered grains of quartz, most abundant in the center. They are very difficultly separated from the remaining rock, and it is thought that they are masses of biotite and segregated from the original chloritic mass, and that their wrinkling indicates an igneous condition of the granite at the time of their separation.†

103. Dana‡ proposes a nomenclature for metamorphism and porphyritic structure in rocks. For the former, *Crystallinic* is suggested for secondary enlargement; *Paramorphic* for the results of paramorphism, and *Metachemic* for the term "metasomatic." In descriptions of porphyritic structure it is proposed that such terms as Orthophyric, Leucitophyric, Augitophyric, Quartzophyric, etc., be used as adjectives to indicate at once the structure and the mineral causing it.

#### PARAMORPHISM, METAMORPHISM, ETC.

The writer is compelled to confine his attention to the American contributions to this subject on account of lack of time and inaccessibility of the literature. The many questions connected with the formation of crystalline rocks are now being discussed by an increasing number of observers, who, with the aid of microscopic petrography, and with wide opportunities for systematic field survey, obtain results vastly more

\*Am. Jour. Sci., III, vol. 3, pp. 321-331 and plate.

†Philadelphia Acad. Sci., Proc. (vol. 37), pp. 19-24.

‡Am. Jour. Sci., II, vol. 32, pp. 69-72.

valuable than those represented by the hypothetical speculations composing the greater part of the past literature on this subject.

104. Becker's memoir on the Cretaceous metamorphic rocks of California will prove especially interesting among those which have appeared during the past year, for his results have been obtained by exceptionally detailed work with every possible auxiliary in a country which is stated to be particularly easy of study. It has been found that sandstones and arkoses of Neocomian age have been altered to crystalline rocks only differing from those of the Archean by holding plagioclase instead of orthoclase, and by irregularity of their alteration. They include metamorphic diabases and diorites and vast quantities of serpentine. These changes have been traced from slight alteration, through all stages of the obliteration of evidence of plastic character, to the final crystalline products. The great masses of serpentine are found to be derived from the sandstones both directly and through intermediate granular metamorphics: "Highly inclined sandstones strike into serpentine areas in such a manner as to wholly preclude the supposition that the serpentine is an older mass, and instances are observed where one side of an anticlinal is serpentinized while the other is unaltered and carries excellent fossils. These relations are particularly clear at Knoxville and Mount Diablo." In discussing the causes of these changes it is thought that they were effected in great part at the time of upheaval by solutions from the underlying granites. It is supposed that these were at first warm and basic and supplied the material for the change to augitic and amphibolic holocrystallines. Serpentinization appears to have followed at a lower temperature, and finally the greater part of the silica was deposited.\*

105. The Trappean and Serpentinous rocks occurring in a considerable area west of Baltimore have been studied in great detail by G. H. Williams, who finds them to consist of what are termed "hypersthene gabbros," gabbro-diorites, peridotites and their alteration and paramorphic products. The first is a fine-grained, purplish-black aggregate of hypersthene, diallage, and plagioclase. The second is a dark green rock of fibrous hornblende, and the third form a series characterized principally by a large amount of olivine, and are referred to the family of peridotites. The first two graduate into each other in the field, and microscopic examination reveals the gradual transition of the second from the first by change of pyroxene to fibrous-hornblende, and some other interesting special features. The peridotites break through the other in dikes. They are rarely rich in feldspar, and sometimes this is absent. By gradual loss of olivine they grade into another massive rock composed almost wholly of diallage and hypersthene. The olivine always appears to alter to serpentine, and the pyroxene (no matter what its form) to hornblende, which suffers further alteration to talc, with separation of calcite. In the main the hornblende serpentines, as those of Bare Hills,

\*Am. Jour. Sci., III, vol. 31, pp. 348-357.

etc., have been formed from eruptives composed of olivine and bronzite, similar to rocks now found unaltered in their vicinity.\*

106. The origin of the ferruginous schists and iron ores of the Lake Superior district has long been a subject of controversy. In a recent paper on this subject, Irving discusses the several theories which have been held and gives a summary of the results of a detailed study of the ores and schists into which they grade. The general conclusions arrived at are as follows: In its original condition, the ore-bearing beds consisted of a series of thinly bedded more or less highly ferriferous carbonates, interstratified with and grading into carbonaceous shales closely simulating the beds of carbonates in the coal measures. By a process of silicification part of the siderite in these beds was broken up and replaced by silica and the iron segregated into seams, layers, and impregnations in a more highly oxidized condition, but it is thought that in some places the silicifying waters<sup>†</sup> have given rise to actinolitic magnetite-schists and intermediate products. At some points the sideritic constituent in the original beds appears to have been oxidized in place, but the larger hematitic deposits are unquestionably secondary.<sup>‡</sup>

107. Van Hise, in a paper on the origin of the mica schists and black mica slates of the Penokee-Gogebie iron-bearing series, gives an account of their lithologic characteristics, and discusses the mode of their formation from clastic materials. Followed along the strike, the quartzites, slates, and graywackes are found to change through biotitic and chloritic graywackes to mica schists, forming the main mass of the formation, by alteration of the feldspar and biotite to muscovite with separation of silica; "the result being a production from a completely fragmental rock by a metasomatic change, of one presenting every appearance of a complete original crystallization, and which would ordinarily be classed as a genuine crystalline schist." In the western part of the district the feldspathic constituent was apparently in greater proportion, and the rocks there are now entirely mica schists and slates.<sup>†</sup>

108. In a note to the American Journal of Science,<sup>§</sup> Irving corrects his previous statement that Sorby was the first to call attention to secondary enlargement of quartz grains in rocks, and states that Törnebohn made this observation several years before.

109. In a paper before the British Association, entitled "Some Examples of Pressure Fluxion in Pennsylvania," Lewis describes his studies upon some localities where evidences of this phenomena is found. The principal one is the belt of Laurentian rocks crossing the Schuylkill 20 miles above Philadelphia, which are considered to be purely of eruptive origin, consisting of syenites, acid gabbros, trap granulites, and other

\* U. S. Geol. Survey, Bulletin (No. 23), vol. 4, pp. 615-688, and 4 plates.

† Am. Jour. Sci., III, vol. 32, pp. 255-272.

‡ Am. Jour. Sci., III, vol. 31, pp. 453-459.

§ Vol. 31, pp. 225-226.



igneous rocks often highly metamorphosed. The rocks are massive in the center of this belt, but the outer portions have "been enormously compressed, folded, and faulted, with the result of producing a tough, banded, porphyritic fluxion gneiss, identical with the milonite of Lapworth or the sheared gneiss of Peach and Horne. So perfect is the fluxion structure that the rock resembles a rhyolite. As in the banded granulite of Lehmann, elongated feldspar eyes lie in flowing streams of biotite grains and broken quartz, the streams often parting and again meeting around the porphyritic eyes. Occasional crystalline eyes of hornblende remain, but most of it has been converted into biotite.

A point of especial interest is that the feldspar of the eyes is quite colorless and free from inclusions, like the sanidine of recent lavas; while, on the other hand, the feldspars of the inner and massive portions of the zone, out of which this outer portion has been reformed by pressure fluxion, are full of inclusions and have the dusty appearance so common in ancient feldspars. The fresh-looking feldspar eyes have therefore very possibly been subsequently formed as the result of a recrystallization of the old material under the influence of pressure fluxion. In similar manner the biotite has been made out of the old hornblende, garnets have been developed, and quartz has been granulated and optically distorted by pressure. Associated Cambrian strata with *Scolithus* stems shows evidence of the great pressure, and its stems and pebbles are pulled out and flattened. Other localities are found showing various phases of lamination by pressure, and it is expected that further study will reveal more.\*

110. Another paper bearing on the same subject is one by Lawson, entitled "Some Instances of Gneissic Foliation and Schistose Cleavage in Dikes and their bearing upon the Problem of the Origin of the Archean Rocks." Its author describes a number of granitic and dioritic dikes in the Lake of the Woods region in which schistose structure is developed parallel to their walls, and it is thought these instances prove conclusively that gneissic foliation is not a proof of bedding. Upon this premise it is suggested that the gneissic rocks of the Laurentians and elsewhere may not be sediments metamorphosed in place, but intrusives in which the foliation was induced by pressure, and that their puckering and crumplings may be due to the increase of bulk during the crystallization process. To account for the lamination and alternation of beds in the younger gneisses it is supposed that they were under less pressure and more liquid, so that their materials could separate into zones determined by specific gravity and melting points.†

111. In a paper on supermetamorphism Comstock calls attention to instances in the San Juan district where Silurian and Devonian beds grade into a granitic rock which is underlain by quartzite.‡

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\* Report (Trans., pp. 1029-1030).

† Canadian Inst. Proc., vol. 22, pp. 115-128.

‡ Am. Naturalist, vol. 20, pp. —.



112. Dale, in a paper on the metamorphism in the Rhode Island coal basin, describes an area north of that previously studied, in which the beds are greatly disturbed and the alteration intense. The slates and clays are found changed to mica schists, holding garnet, staurolite, etc., and separated from equally crystalline beds, at least in part of Paleozoic age, by plumbaginous argillite, with veins of mica and coal ferns.\*

113. *Kaolinization*.—Lesley, in a paper on the kaolin of southeastern Pennsylvania, discusses kaolinization, and suggests that this process and the resulting rock decay may be greatly increased by the presence of limestone. It is thought that this would account for some of the features observed in the district studied and in various belts of specially decayed rocks; for instance, on the eastern side of Hoosac Mountain and in parts of the Southern States.† The relation of decay to joint planes is also considered, and Ashburner,‡ in an examination of a kaolin deposit in Delaware County, finds evidence confirming Lesley's views.

114. *On the origin of coal*.—Lesquereux, in a very interesting and suggestive paper on this subject, urges the peat-bog theory with a great mass of evidence from his own observations in the European peat bogs and the coal measures of the United States.§

#### TOPOGRAPHIC FEATURES OF LAKE SHORES.

115. In a paper on this subject Gilbert discusses the several agents concerned in the formation of the shores of water bodies in which tidal action was insignificant in its results. The studies leading to the memoir were in large part upon the topographic features of the lacustral deposits of the great fossil lakes of the Great Basin, and supplemental observations have been made on the shores of some existing lakes. Omitting considerations of tidal action, the agents concerned in the production of shore features are waves and currents created by the wind. The wind which drives waves toward a shore produces also a system of currents—superficial currents toward the shore and along the shore, and an inferior current, the undertow, away from the shore. The waves erode, and the waves and shore current in combination transport the eroded material, shore drift, in the direction of the shore current. Under certain clearly indicated conditions the shore drift is deposited, its accumulation taking the form of spits, bars, hooks, etc. In the region of erosion the land is planed away just below the water surface, and this planed surface in the fossil condition becomes a terrace. The shoreward limit of erosive action is marked by a cliff. In

\* Canadian Inst. Proc., vol. 22, pp. 18-21.

† Second Geological Survey of Pennsylvania, Annual Report for 1885, pp. 571-591.

‡ *Ibid.*, pp. 593-614.

§ *Ibid.*, pp. 95-124.

the region where there is neither erosion nor deposition, but transportation only, the shore drift takes the form of a beach, and if the land is gently inclined a lagoon is separated behind the beach, which is then called a barrier. Points of land are usually eroded by waves, while bays are filled or partitioned off by bars; the waves of a lake thus tend to straighten its shores. Other shore features treated are the delta, whose anatomy as well as morphology is described, and the shore wall, a feature resulting in cold climates from the expansive force of ice.

The topographic elements constituting shores have sometimes been confused with similar elements of different origin, and the criteria for discrimination are therefore discussed. A sea-cliff is compared with cliffs resulting from the unequal hardness of strata, from lateral wear by streams, from faulting, etc. Shore terraces are compared with terraces arising from alternations of hard and soft strata, stream terraces, fault terraces, etc. Barriers and other shore structures constituting ridges are compared with moraines and osars.\*

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\* U. S. Geol. Survey, Fifth Annual Report, pp. 67-123.



# NORTH AMERICAN PALÆONTOLOGY FOR 1886.

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By JOHN BELKNAP MARCOU.

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Translation of a portion of the resolutions concerning nomenclature and colors voted by the International Geologic Congress at the meetings of the 27th, 28th, 29th, 30th of September and 1st of October, 1881. (Extracted from the "Compte rendu de la 2me Session, Bologne, 1881, Congres Geologique International, p. 198.")

## RULES TO BE FOLLOWED IN ORDER TO ESTABLISH THE NOMENCLATURE OF SPECIES.

1. The nomenclature adopted is that in which each being is designated by a generic and a specific name.
2. Each of these names is composed of a single Latin or Latinized word, written according to the rules of Latin orthography.
3. A species may present a certain number of modifications, connected together in time or space, and designated respectively under the name of Mutations or of Varieties; modifications having a doubtful origin are simply called Forms. Modifications will be indicated, when necessary, by a third term preceded, according to each case, by the words variety, mutation, or form, or by the corresponding abbreviations.
4. The specific name should always be defined by indicating the name of the author who established it; this author's name is placed in parenthesis when the primitive generic name is not kept, and in this case it is useful to add the name of the author who changed the generic reference. The same process is applicable to varieties when elevated to species.
5. The name attributed to each genus or to each species is that under which they have been designated the longest on condition that the characters of the genus and of the species shall have been published and clearly defined. Priority will not go back beyond Linnæus, twelfth edition, 1766.
6. In future, for specific names, priority will have been irrevocably acquired only when the species shall have been not only described, but also figured.

The President:

J. CAPELLINI.



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ALDRICH, T. H. Preliminary Report upon the Tertiary Fossils of Alabama and Mississippi. Geol. Surv. Alabama, Bulletin No. 1, pp. 18 60, pls. i-vi, 1886.)

Part I. Notes and descriptions of species describes *Expleritoma* nov. gem., and the following new species: *Murex matthewsensis*, *M. simplex*, *Trophon gracilis*, *T. caudatoides*, *Pseudoliva unicarinata*, *Ranella* (*Argobuccinum*) *Tuomeyi*, *Fusus Meyeri*, *F. tombigbeensis*, *F. rugatus*, *Fasciolaria pergracilis*, *Leucozonia biplicata*, *Bulbifusus plenus*, *B. Tuomeyi*, *Neptunea constricta*, *Pyropsis perula*, *Pisania* (?) *dubia*, *Buccinum Mohri*, *Cominella hatchetigbeensis*, *C. striata*, *Massa calli*, *Turbinella baculus*, *Voluta Showalteri*, *Mitra hatchetigbeensis*, *Ancillaria expansa*, *Expleritoma prima*, *Pleurotoma perexilis*, *P. exilloides*, *P. tombigbeensis*, *P. Tuomeyi*, *P. (Ancistrosyrix) columbaria*, *Aphorais gracilis*, *Cypræa Smithii*, *Natica recurva*, *Capulus compectus*, *Cerithium tombigbeense*, *Melanopsis anita*, *Trochus alabamensis*, *Haminea grandis*, *Teredo circula*, *Pholas alatoidea*, *Martesia elongata*, *Solen lisbonensis*, *Panopæa porrectoides*, *Neera prima*, *N. alternata*, *Pholadomya claibornensis*, *Cytheria hatchetigbeensis*, *Cardium Tuomeyi*, *C. hatchetigbetrense*, *Nucula mauroensis*, *Pecten* (*Pleuronectia*) *alabamensis*, *Anomia ephippoides* Gabb., var. *lisbonensis* (new var.), *Ostrea johnsoni*.

This fauna seems to be confined to the Lower Claibornian, above the Buhrstone.

Part II.—Geological Distribution and Localities of Species.

The following divisions are made: White Limestone group, Ferruginous Sand-bed (Claiborne Sand), Middle and Lower Claibornian, Hatchetigbee group, Wood's Bluff group, Bell's Landing group, Nanafalia group, Matthews's Landing group, Black Bluff group, and Midway group.

ALDRICH, T. H. Notes on the Distribution of Tertiary Fossils in Alabama and Mississippi. (Jour. Cincinnati Soc. Nat. Hist., vol. VIII, pp. 256, 257, January, 1886. Cincinnati.)

Mentions the occurrence of *Orbitoides supera* Conrad, *O. Mantelli* Conrad, and a few Nummulites in beds immediately underlying the strata in which the Zeuglodon bones occur at Jackson, on Dry or Town Creek.

Mentions the finding of a *Nautilus* sp.? at Vicksburg, Mississippi, in the Oligocene, and also a new species of crab from Alabama.

ALDRICH, T. H. and MYER, OTTO. Geological Survey of Alabama. Parts I and II. Tuscaloosa. Geol. Surv. 1886. 8vo. Science, Vol. VIII. No. 196, pp. 421-422, November, 1886. New York. Review of and abstract from.

ALDRICH, T. H. (See Myer, Otto.)

ALLEN, J. A. On an extinct type of Dog from Ely Cave, Lee County, Virginia. Published by permission of N. S. Shaler and J. R. Proctor, directors of the Kentucky Geological Survey. With three plates. (Mem. Museum Comp. Zool. at Harvard College, vol. x, pp. 1-13, pls. i-iii. December, 1885. Cambridge.)

Describes the new genus *Pachycyon* and the new species *P. robustus*.

Prof. N. S. Shaler, pp. 9-13, furnishes a note "On the Age of the Ely Cave."

In this he states that the caves in the Cambro-Silurian series, of which this is one, are often found under conditions such as to make it certain of their having come down from times so remote that we may fairly hope to find within them fossils of the Pliocene age.

ALLEN, J. A. An extinct Dog. (Mem. Mus. Comp. Zool. Cambridge, Amer. Nat., vol. xx, p. 274, March, 1886. Philadelphia.)

Abstract of.

AMI, HENRY M. Additional Notes on the Geology and Paleontology of Ottawa and Vicinity. Read March 4, 1885. (Extracted by permission from Trans. No. 6, (vol. II, No. 2) Ottawa Field Nat. Club., pp. 1-9, 1886. Ottawa.)

AMI, HENRY M. On the occurrence of *Scolithus* in Rocks of the Chazy Formation about Ottawa, Ontario. (Canad. Rec. Sci., vol. II, No. 5, pp. 304-306, 1887. Montreal.)

Mentions two instances of the occurrence of *Scolithus* in Chazy beds, from which it follows that the occurrence of *Scolithus* remains does not necessarily indicate the existence of Potsdam rocks, but that the beds may possibly be newer and higher up in the series.

The extras were distributed in December.

AMI, HENRY M. (See Bailey, L. W.; Ellis, R. W.)

ASHBURNER, CHARLES A., and ANGELO HEILPRIN. Report on the Wyoming Valley Carboniferous Limestone Beds. By Charles A. Ashburner, geologist in charge of the Anthracite Survey; and corresponding member of the Wyoming Historical and Geological Society; accompanied by a Description of the Fossils contained in the Beds, by Angelo Heilprin, professor of invertebrate paleontology, Academy of Natural Sciences, Philadelphia. (Proc. and Collections Wyoming Hist. and Geol. Soc., vol. II, pt. 2, pp. 254-277, 1886. Wilkes Barre, Pennsylvania.)

Descriptions of the species, with numerous illustrations in the text (pp. 265-277). No new species are described. The author considers the fossils undoubted evidence of the Carboniferous age of the formation, although some people may have thought that they belonged to the Permian.

BAILEY, L. W. Report of Explorations and Surveys in Portions of the Counties of Carleton, Victoria, York, and Northumberland, New Brunswick, 1885. (Ann. Rep. Geol. and Nat. Hist. Surv. Canada, new ser., vol. I, pp. 18-309, 1886. Montreal.)

Has a note by Mr. Whiteaves on the graptolites, from which it appears that the beds in question belong to the Silurian system, as recently restricted in the publications of the survey. These beds are near Campbell's mill (pp. 15g. and 16g).

Gives a list of fossils from Perth, determined by Mr. H. M. Ami, from an horizon not higher than the Lower Helderberg nor lower than the Niagara.

BARCENA, MARIANO. The Fossil Man of Peñon. (Amer. Nat., vol. XX, pp. 633-635, July, 1886. Philadelphia.)

Defends the importance of the discovery and describes the beds in which the bones were found, and states that all his observations induce him to believe in the contemporaneity of the man of Peñon and of the mammoth in the valley of Mexico.

BARRIS, W. H. A Defense of our Local Geology. (Proc. Davenport, Acad. Nat. Sci., vol. V, pp. 15-22, 1886. Davenport.)

A criticism of a pamphlet on the "Geology of Scott County, Iowa, and Rock Island County, Illinois," by A. S. Tiffany. Originally read as an address

## BARRIS, W. H.—Continued.

before the Academy, it is published in such form rather than as a more rigidly strict scientific paper.

States that in Mr. Tiffany's paper there are no less than one hundred and eighty-five blunders in the naming of fossils.

BARRIS, W. H. Bad Blunders. Those Committed in the Naming of the Fossils of Scott County in a Recent Pamphlet—Barris's Criticisms. (From Davenport Daily Gazette, March 2, 1886.)

A criticism of a paper by A. S. Tiffany.

BAUR, G. Ueber die Kanäle im Humerus der Amnioten. (Morphologisches Jahrbuch. Band XII, Heft II, pp. 299–305, 1886. Leipzig.)

I. Canalis entepicondyloideus. II. Canalis ectepicondyloideus. III. Beide Kanäle zugleich.

BAUR, G. Ueber die Morphogenie der Wirbelsäule der Amnioten. (Biologisches Centralblatt. Band VI, Nr. 12, pp. 353–363. 15th August, 1886. Erlangen.)

BAUR, G. The Morphogeny of the Vertebral Column in the Amniota. Ueber die Morphogenie der Wirbelsäule der Amnioten. Biologisches Centralblatt, 15th August, 1886. Amer. Nat., vol. XX, p. 956. November, 1886. Philadelphia.

Brief review of the article which indorses Cope's view that the intercentrum in *Archegosaurus* is a distinct body, intercalated between the true centra, which he regards as represented by the two pleurocentra.

BISHOP, J. P. On certain Fossiliferous Limestones of Columbia County, New York, and their relation to the Hudson River Shales and the Taconic System. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 438–441. December, 1886. New Haven.)

Describes a discovery of fossils in a metamorphic limestone on the western border of the Taconic slates, in Columbia County, New York. This limestone is divided into two arms which appear to blend at Kinderhook Lake. The fossiliferous localities are three in number, and all are in the eastern belt. From the first, situated midway between Chatham and Ghent, only crinoid stems have been taken. The second is situated at the crossing of the New York and Mahopac Railroad, 2 miles north of Chatham; and the third a mile still farther north, on the farm of Mr. Joel Angell; and these two have furnished the fossils mentioned. Several well-marked valves of *Leptæna sericea* and *Strophomena alternata*. The external markings of the gasteropods are so effaced by metamorphism and weathering that it is very difficult to distinguish species. There are several species of a slender *Murchisonia*, probably *M. gracilis*, a single doubtful *Maclurea* and specimens of *Ophileta* in abundance, one incomplete *Orthoceras*, and a well-preserved new species of the genus *Ptilodictya*.

Considers these fossils of Trenton age, and that there can be no reasonable doubt that this limestone containing Trenton fossils immediately underlies the graptolitic shales of the Hudson River group.

BRANCO. (Review.) O. C. MARSH. Dinocerata. A monograph of an extinct order of gigantic mammals. (U. S. Geol. Surv., vol. X, Washington, 1884. Gross 4to. XVIII u. 237 Seiten, Mit 200 Holzschnitten u. 56 Tafeln. Neu. Jahrb. für Min., Geol. u. Pal., 1886. Band I, pp. 339–341. Stuttgart.)

Abstract.

**BRAUER, FRIEDRICH.** Ansichten über die paläozoischen Insecten und deren Deutung, von. Prof. Dr. Friedrich Brauer. Mit zwei photozinkogr. Tafeln (No. VII und VIII). (Annalen des K. K. Naturhistorischen Hofmuseums. Redigirt von Dr. Franz Ritter von Hauer (Mit sieben Tafeln und drei Figuren im Texte). Band 1, No. 2, pp. 87-126, 1886. Wien.)

Criticises much of Scudder's work.

**BRITTON, N. L.** Fossil leaves in Staten Island and Long clay beds. (Trans. N. Y. Acad. Sci., III., 30. Amer. Jour. Sci., 3d ser., vol. XXXI, p. 403, May, 1886. New Haven.)

Notice of Cretaceous leaves. (See last year's record.)

**BRITTON, N. L.** Account of a cruise along the shores of Staten Island and New Jersey. (Proc. Nat. Sci. Assoc., Staten Island, September, 1886. New Brighton.)

Mentions a good exposure of the Lower Cretaceous marl-bed at Atlantic Highlands, New Jersey, and the presence of several species of fossils there; several hundred specimens were collected.

**BRÖGGER, W. O.** Om alderen af Olenelluszonen i Nordamerika. (Geol. Foreningens i Stockholm Forhandl., No. 101. Bd. VIII, H. 3, pp. 182-213.) 1886, Stockholm.

An attempt to prove that the Olenellus beds are older than the Paradoxides beds, and to establish a parallelism between part of the forms in the older divisions of the American and Scandinavian primordial faunas. The author thinks he has demonstrated that the Olenellus zone in America as well as in Europe represents the oldest trilobite-bearing fauna so far known. Outside of America the genus *Olenellus* is represented by the one species only of *O. Wahlenbergii*, Torell, = *O. Kjerulfi*, Linrs. (Which is quite probably a Paradoxides.)

**BRONGNIART, CHARLES.** The Fossil Insects of the Primary Group of Rocks, a rapid survey of the Entomological Fauna of the Palaeozoic Systems. (Manchester Geol. Soc. Transactions, vol. XVIII, parts 10-19 (1884-'86), p. 269. 1885-'86, Manchester.)

Not seen. See record for 1885, p. 716, same paper.

**BRONGNIART, CHARLES.** Fossil Insects of the "Primary" (Paleozoic) rocks, 20 pp., 8vo., with five plates. (Bull. Soc. Sci. Nat. Rouen, 1885. Amer. Jour. Sci., 3d ser., vol. XXXI, p. 156. February, 1886. New Haven.)

Notice of.

**CALL, R. ELLSWORTH.** On the Genus *Campeloma*, Rafinesque, with a Revision of the Species, Recent and Fossil. (Bull. Washburn College Laboratory Nat. Hist., vol. I, No. 5, pp. 159-165, pls. III-VI. May, 1886. Topeka, Kansas.)

There are four forms of fossil *Campeloma* mentioned in this revision of the genus.

**CALL, R. ELLSWORTH.** (See McGee, W J)

**CANU, E.** L'articulé problématique des dépôts tertiaires de Florissant, *Planocephalus aselloides*, Scudder. (Soc. Géol. du Nord, Annales, Tome XIII, 1885-'86, livr. 1-3, p. 148. Lille.)

Not seen.



CARPENTER, P. HERBERT. Revision of the Palaeocrinoidea, Part III. Discussion of the Classification and Relations of the Brachiate Crinoids and Conclusion of the Generic Descriptions, by Charles Wachsmuth and Frank Springer. First section extracted from the "Proceedings of the Academy of Natural Sciences," July 28, 1885. Philadelphia, 1885. Pp. 138, pls. IV-IX. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVII, pp. 277-289. March, 1886. London.)  
Review of.

CARPENTER, P. HERBERT. Note on the Structure of *Crotalocrinus*. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVIII, pp. 397-406, fig. p. 402. November, 1886. London.)

A review of Messrs. Wachsmuth and Springer's views on the structure of the genus. The author concludes that in any case they will no longer be able to refer to this family as Palaeocrinoids, which "probably have hydrospires within the calyx," and to use this supposed fact as an illustration of their theory that Blastoids, Cystids, and Crinoids are so closely linked together, that they are not entitled to rank as classes of Echinoderms equivalent to the Urchins and Starfishes.

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CARPENTER, P. HERBERT. (See Etheridge, Robert, jun.)

CHALMERS, R. Preliminary Report on the Surface Geology of New Brunswick. (Ann. Rep. Geol. and Nat. Hist. Surv. Canada, new ser., vol. I, pp. 199-539, 1886. Montreal.)

Gives a list of Post-Tertiary fossils, collected in 1884, from the Leda clay of the south side of the Baie des Chaleurs, and describes their mode of occurrence.

CLARKE, J. M. On the higher Devonian Faunas of Ontario County, New York. 80 pp., 8vo., with three plates. Bull. No. 16, U. S. Geol. Survey, Washington, 1885. (Amer. Jour. Sci., 3d ser., vol. XXXI, p. 404. May, 1886. New Haven.)

Abstract of.

CLARKE, J. M. (See Kayser.)

CLAYPOLE, E. W. Report on some fossils from the lower Coal Measures near Wilkesbarre, Luzerne County, Pennsylvania. (Proc. and Coll. Wyoming Hist. and Geol. Soc., vol. II, pt. 2, pp. 239-253, figs. 1-4 on p. 244, 1886. Wilkesbarre, Pennsylvania.)

Describes the new species *Modiomorpha (?) parvula*. Many of the species are comparable, if not identifiable, with Western forms.

CONGDON, E. A. Remarks upon a deposit of infusorial earth on the south shore of Clove Lake, Staten Island. (Proc. Nat. Sci. Assoc., Staten Island. May 8, 1886. New Brighton.)

Gives a list of the species found, all of which, with three exceptions, are also found living.

COPE, EDWARD DRINKER. Second Continuation of Researches among the Batrachia of the Coal Measures of Ohio. Read before the American Philosophical Society, June 19, 1885. (Proc. Amer. Phil. Soc., Vol. XXII, pp. 405-408, October, 1885. Philadelphia.)

Describes the new genus and species *Cercurimorphus parvisquamis*, gen. et sp. nov., and the following new species: *Anisodexis enchodus*, *Ceraterpeton divaricatum*. He also describes what he considers to be "Claspers of Bratrachia."

COPE, E. D. The Genealogy of the Vertebrata as learned from Paleontology. An address delivered before the Vassar Brothers Institute, January 27, 1885. Trans. Vassar Bros. Inst., vol. III, pt. 1, 1884-'85, pp. 60-80. Poughkeepsie, 1885.)

In conclusion, the progressive may be compared with the retrogressive evolution of the Vertebrata, as follows: In the earlier periods and with the lower forms, retrogressive evolution predominated. In the higher classes, progressive evolution has predominated. When we consider the nature of the first class of vertebrates (the Tunicata) in this respect, and compare it with that of the last class (the Mammalia), the contrast is very great.

COPE, E. D., and WORTMAN, J. L. The mammalian fauna of the Post-pliocene deposits. Fourteenth Annual Report of the Geology and Natural History Survey of Indiana; John Collett, director. (Amer. Nat., vol. XX, p. 48, January, 1886. Philadelphia.)

Brief abstract of.

COPE, E. D. The Sternum of the Dinosauria. (Amer. Nat., vol. XX, pp. 153-155, figs. 1, 2, February, 1886. Philadelphia.)

Some evidence as to the nature of the sternum in the Dinosauria, and the presence or absence of clavicles in this order.

COPE, E. D. Corrections of Notes on Dinocerata. (Amer. Nat., vol. XX, p. 155, February, 1886. Philadelphia.)

In the Naturalist for June, 1885, the author gave a synopsis of the genera of this suborder, which was partly based on information derived from Professor Marsh's work. Among them was included the supposed genus *Tetheopsis*, whose character consisted in the absence of inferior canine and incisor teeth. The author now learns on good authority that the symphyseal region in the specimen in question is entirely constructed of plaster of Paris. The genus *Tetheopsis* must then be regarded as an artifact.

The basal part of a skull which the author described under the head of *Uintatherium lacustre*, Marsh (U. S. Geol. Survey Terr., III, p. 592), turns out to belong to a *Palaeosyops*.

COPE, E. D. Prof. E. D. Cope, on a New Type of Perissodactyle Ungulate from the Wasatch Eocene of Wyoming Territory, United States of America. (Geol. Mag., new ser., Decade III, vol. III, pp. 49-52, pl. II, February, 1886. London.)

A description of the genus *Phenacodus* with a figure of *Phenacodus primaris* Cope, reproduced through the kindness of Professor Cope.

COPE, E. D. Edestus and Pelecopterus, etc. (Geol. Mag., new ser., Decade III, vol. II, p. 141, March, 1886. London.)

Notes that *Ptychodus* being a shark, is not likely to have a pectoral arch and fin like that of *Pelecpterus*. "Moreover these pectoral spines have been

## COPE, E. D.—Continued.

frequently found associated with the jaws and teeth of the 'snout fishes' of the Kansas Chalk, which have been described under the generic head of *Erisichthe* Cope. Several species are known (see Bulletin U. S. Geol. Survey Terrs., III, 1887), and one of them is probably the *Xiphias Dixoni* of Agassiz, from the chalk of Sussex, England. These genera can not be referred to any of the existing orders of fishes, on account of the peculiar structure of the pectoral arch. The author therefore places them in an especial one, the *Actinopteri* (see Proceedings Amer. Assoc. Adv. Science, 1877-'78, p. 299).

COPE, E. D. Upper Miocene (Loup Fork Beds) in eastern Mexico. (Amer. Nat., 1885, p. 494; Amer. Jour. Sci., 3d ser., vol. XXXI, p. 310, April, 1886. New Haven.)

Abstract of.

COPE, E. D. The Vertebrate Fauna of the Ticholeptus Beds. (Amer. Nat., vol. XX, pp. 367-369, April, 1886. Philadelphia.)

Gives lists of the species found in the Ticholeptus bed on the Cottonwood Creek, Oregon, and in Montana; the only species common to both lists is the *Blastomeryx borealis*. The Ticholeptus horizon is interesting as that in which the genus Mastodon makes its first appearance in America. It is now shown to be the last which contains the genus Anchitherium. It is intermediate in all respects between the Middle and Upper Miocene formations of the West, as represented by the John Day and Loup Fork beds.

COPE, E. D. The Plagianaulacidae of the Puerco Epoch. (Amer. Nat., Vol. XX, p. 451, May, 1886. Philadelphia.)

Reviews briefly the three species already described from this group, and describes the new species *Neoplagianaulax molestus*, from an entire inferior fourth premolar.

COPE, E. D. Notes on Phenacodus. (Geol. Mag., new ser., Decade III, vol. III, pp. 238-239, May, 1886. London.)

States that in the article in the Geological Magazine for February, pp. 49-52, pl. II, the editor omitted to state the author's more mature views published in the American Naturalist for 1885 and for 1884.

It thus appears that Lemurine forms were the ancestors of all Placental Mammalia, as was already anticipated by Haeckel in his far-seeing "Schöpfungsgeschichte."

COPE, E. D. Note on Erisichthe. (Geol. Mag., new ser., Decade III, vol. III, p. 239, May, 1886. London.)

Defends the use of the name *Erisichthe*, against Mr. Davies's note in the March number of the Geological Magazine, where he wishes him to use the name *Protosphyrapna* Leidy.

COPE, E. D. Vertebrata of the Swift Current Creek region of the Cypress Hills. (Ann. Rep. Geol. and Nat. Hist. Surv. Canada, 1885. New series, vol. I, pp. 79c-85c. Published May, 1886. Montreal.)

The region mentioned is in the district of Assiniboia, Northwest Territory, about longitude 109, latitude 49° 40'. The author considers the beds in question to belong to the White River or Oligocene epoch.

Describes the new species *Menodus angustigenis*, and mentions generically another species of *Menodus* and two species of *Testudinata*, *Trionyx*, and *Stylemys*, sp.

COPE, E. D. The long-spined Theromorpha of the Permian Epoch. (Amer. Nat., vol. xx, pp. 544, 545, June, 1886. Philadelphia.)

Discusses some of the characters of *Dimetrodon incisurus*, *D. claviger*, *Naosaurus cruciger*, *N. microdus*, and *N. claviger*; all from the Permian formation of Texas, and says that figures of *N. claviger* will be published in the Transactions of the American Philosophical Society.

COPE, E. D. The Phylogeny of the Camelida. (Amer. Nat., vol. xx, pp. 611-624, figs. 1-14. July, 1886. Philadelphia.)

The total number of genera is nine, of species twenty-six. The development of the camels in North America presents a remarkable parallel to that of the horses. The ancestors of both lines appear together in the Wasatch or lowest Eocene, and the successive forms develop side by side in all the succeeding formations. Camels and horses are standard types in all our Tertiary formations; and they must be learned by any one who wishes to distinguish readily the horizons one from the other. The horse forms are more numerous in all the beds in individuals as well as in species.

COPE, E. D.—Schlosser on the Phylogeny of the Ungulate Mammalia. Beiträge zur Kenntniss der Stammesgeschichte der Hufthiere und Versuch einer Systematik der Paar-und Unpaarhufer, von Max Schlosser. Morphologisches Jahrbuch, Leipzig, 1886. (Amer. Nat., vol. xx, pp. 719-721. August, 1886. Philadelphia.)

Review of.

COPE, E. D. Schlosser on Credonta and Phenacodus. Ueber das Verhältniss der Cope'schen Credonta zu den übrigen Fleischfressern. Morphologisches Jahrbuch, 1886, p. 287, von Dr. Max Schlosser. (Amer. Nat., vol. xx, pp. 965-967. November, 1886. Philadelphia.)

Review and criticism of.

COPE, E. D. An interesting connecting Genus of Chordata. (Amer. Nat., vol. xx, pp. 1027-1031, fig. 1. December, 1886. Philadelphia.)

Describes the new genus and species *Mycterops ordinarius* from the Carboniferous of Pittston, Pennsylvania.

COPE, E. D. A giant Armadillo from the Miocene of Kansas. (Amer. Nat., vol. xx, pp. 1044-1046, December. 1886. Philadelphia.)

Describes the new genus and species *Caryoderma snorianum* from the Loup Fork bed of Kansas.

COPE, E. D. Letters referring to the completion of the final report of the United States Geological Survey of the Territories. pp. 1-7. January, 1887. Washington.

Publishes various letters showing the importance of finishing his work on the fossil Vertebrata of the West.

COPE, E. D. On the Intercentrum of the Terrestrial Vertebrata. Read before the American Philosophical Society, January, 1886. (Trans. Amer. Philos. Soc., Phila., vol. xvi, 2d ser., pp. 243-253, figs. 1-6, pl. i, 1886. Philadelphia.)

That the intercentrum exists is shown by the very frequent occurrence in the Polycosaurian reptiles of the Permian epoch of a wedge-shaped bone be-



## COPE, E. D.—Continued.

tween the vertebral centra on their inferior side. Apparently homologous elements occur in the dorsal and cervical regions of *Sphenodon*, and in the cervical regions of various other lizards. Similar pieces are found in the dorsal and caudal regions of various mammalia, for instance, *Erinaceus*. But in general they are wanting from the Mammalia, and are better developed in the *Polycosauria* than in any other order of reptiles.

Considers it probable that we have in the *Embolomeri* that order of Batrachia from which the Reptilia were derived, through intermediate forms not yet discovered. And that the *Sphenosauridæ* can not be referred to this order as proposed by him, but constitute a family of *Rhachitomi*.

Thinks that the development of the dorsal part of the vertebral column in *Cricotus* is in an opposite direction to that stated by Fritsch to characterize the *Sphenosauridæ*. This is the main point to be proven. If further he has shown that the larger dorsal bodies of *Cricotus* are homologous with the centra of the *Polycosauria* and *Lacertilia*, the proposition remains proven that the inferior vertebral bodies of the *Rhachitomi* and the entire vertebral bodies of existing *Batrachia* are intercentra and not centra.

## COPE, E. D. The Origin of the Fittest: Essays on Evolution.

(Pp. i-xix and 1-467, pls. i-xviii, figs. 1-81, 1887. New York.)

Although dated 1887 this book appeared in the latter part of 1886. It contains the reflections which have suggested themselves to the author while engaged in special zoological and paleontological studies. The latter essays have resulted chiefly from the author's researches in the field of vertebrate paleontology, which have thrown the greatest possible light on the fact and method of evolution. The work is divided as follows:

Part I. General Evolution. I. Evolution and its Consequences. II. The Origin of Genera. III. The Theory of Evolution. IV. The Hypothesis of Evolution, Physical and Metaphysical. V. The Method of Creation of Organic Forms. VI. Review of the Modern Doctrine of Evolution.

Part II. Structural Evidence of Evolution. VII. The Homologies and Origin of the Types of Molar Teeth of the Mammalia *Educabilia*. VIII. The Relation of Man to the Tertiary Mammalia. IX. The Developmental Significance of Human Physiognomy. X. The Evidence for Evolution in the History of the Extinct Mammalia. XI. The Evolution of the Vertebrata, Progressive and Retrogressive.

Part III. Mechanical Evolution. XII. The Relation of Animal Motion to Animal Evolution. XIII. On the Trituberculate Tooth in the Mammalia. XIV. The Origin of the Specialized Teeth of the Carnivora. XV. The Origin of the Foot Structures of the Ungulates. XVI. The Effect of Impacts and Strains on the Feet of Mammalia.

Part IV. Metaphysical Evolution. XVII. The Evolutionary Significance of Human Character. XVIII. Consciousness in Evolution. XIX. Archæthetism. XX. Catagenesis. XXI. The Origin of Will.

COPE, E. D. Systematic catalogue of species of vertebrata found in the beds of the Permian epoch in North America, with notes and descriptions. Read before the American Philosophical Society, May 7, 1886. (Trans. Am. Phil. Soc., vol. XVI, pp. 285-297, pls. 11-111. Philadelphia, 1886.)

Describes the new species *Ectocynodon incisiorus*.

COPE, E. D. On the Structure of the Brain and auditory Apparatus of a theromorphous Reptile of the Permian Epoch. Read before the

COPE, E. D.—Continued.

American Philosophical Society, October 16, 1885. (Proc. Amer. Phil. Soc. for 1885, pp. 234–237, 1 pl. Philadelphia, 1886.)

These observations are derived from a part of the skull of one of the *Diadectidae* (*Pelycosauria* in the transverse molar teeth), of a single individual of undetermined species. A few characters are derived from skulls of two allied species, *Diadectes phaseolinus* and *Empedias molaris* Cope, which, like the first-named specimen, were derived from the Permian formation of Texas. The prominent features of this brain are the following: The widest part is at the origin of the trigeminus nerve. Both the cerebellum and optic thalamus are flat and simple. The hemispheres are narrower than the segments posterior to them and of greater vertical diameter. The epiphysis is enormous and sends a process posteriorly between the tables of the parietal bone. The olfactory lobes were apparently large and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and batrachia rather than of reptiles, but the thalami are also smaller than is the case in batrachia. The small, flat cerebellum is rather batrachian than reptilian.

The result of this examination into the structure of the auditory organs in the *Diadectidae* may be stated as follows: The semicircular canals have the structure in common to all *Gnathostomatus Chordata*. The internal wall of the vestibule remains unossified as in many fishes and a few batrachians. There is no rudiment of the cochlea, but the vestibule is produced outwards and upwards to the fenestra ovalis in a way unknown in any other family of vertebrates.

I may add that in the specimen examined the semicircular canals were filled with a white calcareous powder, probably derived from the comminution of otolites.

COPE, E. D. (See Dames; Noetling; Seely, H. G.)

CRAGIN, F. W. Notes on the geology of southern Kansas. (Bull. Washburn College Laboratory Nat. Hist., vol. 1, No. 3, pp. 85–91. April, 1885. Topeka, Kans.)

Mentions the occurrence of quaternary and tertiary vertebrate fossils and cretaceous invertebrate ones.

CUNNINGHAM, K. M. New find of fossil diatoms. (Science, vol. VII, No. 153, p. 35, January, 1886. New York.)

Calls attention to an important new locality in a clay strata in a railroad cutting near Philadelphia.

DALE, T. NELSON. New England Upper Silurian. (Proc. Canadian Inst., 3d ser., vol. IV, pp. 69–70, November, 1886. Toronto.)

Mentions the occurrence of some fossils which have usually been regarded as of Lower Helderberg age, at Littleton, N. H.

DAMES, W. (Review.) J. B. Marcou: A list of the Mesozoic and Cenozoic types in the collections of the U. S. National Museum. (Proc. U. S. Nat. Mus., vol. VIII, 1885, fig. 290ff. Nea. Jahrb. Min., Geol., und Pal., 1886, Band 1, p. 482. Stuttgart.)

Abstract (?).

DAMES, W. (Review.) H. S. Williams: On a Crinoid with movable spines. (Proc. of the Amer. Philos. Soc., 1883, pp. 81–88, 1 Tafel.) G.

J. Hinde: Description of a new species of Crinoid with articulatory

## DAMES, W.—Continued.

spines. (Ann. Mag. Nat. Hist., 1885, pp. 157–173, t. 6. Neu. Jahrb. Min., Geol., und Pal., 1886, Band I, pp. 484–485. Stuttgart.)

Abstract.

DAMES, W. (Review.) J. B. Marcou: A Review of the Progress of North American Palæontology for the year 1884. Smithsonian Report for 1884, 20 S., Washington, 1885. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, p. 100. Stuttgart.)

Abstract.

DAMES, W. (Review.) E. D. Cope: The Ankle and Skin of the Dinosaur, *Diclonius armatus*. American Naturalist, 1885, p. 1208, pl. 37, figs. 1–3. (Neu. Jahrb. Min., Geol., und Pal., 1885, Band II, pp. 287, 288. Stuttgart.)

Abstract.

DAMES, W. (Review.) E. D. Cope: The position of *Pterichthys* in the system. American Naturalist, 1885, pp. 289–291. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, pp. 293, 294. Stuttgart.)

Abstract.

DAMES, W. (Review.) A. S. Packard: The Syncarida, a group of Carboniferous Crustacea. American Naturalist, 1885, pp. 700–703. Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, p. 295. Stuttgart.)

Abstract.

DAMES, W. (Review.) A. S. Packard: On the Anthracarida, a family of Carboniferous macrurous decapod Crustacea, allied to the Eryonidæ. American Naturalist, 1885, pp. 880, 881. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, pp. 295, 296. Stuttgart.)

Abstract.

DAMES, W. (Review.) ? A. S. Packard: On the Gampsonychidæ, an undescribed family of fossil Schizopod Crustacea. American Naturalist, 1885, pp. 790–793. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, p. 296. Stuttgart.)

Abstract.

DAMES, W. (Review.) A. S. Packard: Types of Carboniferous Xyphosura new to North America. American Naturalist, 1885, p. 291. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, pp. 296, 297. Stuttgart.)

Abstract.

DAMES, W. (Review.) E. D. Cope: Eocene Paddle-fish and Goniorhynchidae. American Naturalist, 1885, pp. 1090, 1091. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, pp. 385, 386. Stuttgart.)

Abstract.

DAMES, W. (Review.) T. Rupert Jones: On some fossil Ostracoda from Colorado. Geol. Mag., 1886, pp. 145–148, t. 4. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, p. 387. Stuttgart.)

Abstract.

DANA, JAMES D. Lower Silurian Fossils in a limestone of Emmons's original Taconic. Abstract. (Proc. A. A. A. S., vol. xxxiv, pt. 1, pp. 216, 217, 1886. Salem.)

Mentions the discovery of Lower Silurian fossils at several points in the "Sperry Limestone" of Emmons, in the town of Canaan, Columbia County, New York.

DANA, JAMES D. On Lower Silurian Fossils from a limestone of the original Taconic of Emmons. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 241-248, April, 1886. New Haven.)

The same Taconic limestone belt that contains Trenton and Chazy fossils in Rutland, Vermont, and towns farther north, as shown by the Vermont Geological Survey, is now proved to have Lower Silurian fossils west of the Taconic range at Canaan, in eastern New York.

DANA, JAMES D. On Lower Silurian fossils from a limestone of the original Taconic of Professor Emmons. (Nature, vol. xxxiv, p. 68, 1886. London and New York.)

Notice of. See Amer. Jour. Sci., April, 1886.

DANA, JAMES D. The Taconic stratigraphy and fossils. Note. (Amer. Jour. Sci., 3d ser., vol. xxxii, pp. 236-239, September, 1886. New Haven.)

Fossils are not to be looked for in a coarse mica schist or gneiss, or in coarsely crystalline limestone. With even the metamorphic change producing a hydromica schist, the disappearance of fossils is to be expected, though not always a fact; and that producing a coarse mica schist necessarily exterminates fossils. In conclusion, the author believes we may safely regard the Canaan fossils as proof that the limestones and schists of the Taconic system (*sic*) are not older than the Potsdam sandstone.

DANA, JAMES D. (*See* Hinde, George J.)

DARTON, NELSON H. The Taconic Controversy in a Nut-shell. (Science, vol. vii, No. 155, pp. 78, 79, January, 1886. New York.)

States that in his paper entitled "On the occurrence of fossils in the Hudson River slates in Orange County, New York, and elsewhere," he employed the words "Fossils in the Hudson River slates," etc., rather than "Trenton fossils in the Taconian argillite."

DARTON, NELSON H. Preliminary notice of fossils in the Hudson River slates of the southern part of Orange County, New York, and elsewhere. (Nature, vol. xxxiii, p. 285, 1886. London and New York.)

Notice of paper. See American Journal of Science for December, 1885.

DARTON, NELSON H. On the Area of Upper Silurian rocks near Cornwall Station, eastern-central Orange County, New York. (Amer. Jour. Sci., 3d ser., Vol. xxxi, pp. 209-216, March, 1886. New Haven.)

Describes an area of Lower Helderberg limestone and gives lists of fossils found and notes concerning them.

DARTON, NELSON H. On the area of Upper Silurian rocks near Cornwall Station, eastern-central Orange County, New York. (Nature, vol. xxxiv, p. 46, 1886. London and New York.)

Notice of. See American Journal of Science, March.



DAVIES, W. Note on Prof. E. D. Cope's article upon *Edestus* and *Pelecopterus*, etc. (Geol. Mag., new ser., Decade III, vol. III, pp. 141, 142, March, 1886. London.)

"Professor Cope is, I think, mistaken in assigning *Xiphias Dixoni* to Agassiz.

The name first appears in a paper by Dr. Leidy "On *Saurocephalus* and its Allies," in the Trans. Amer. Philos. Soc., vol. XI, p. 91, where the name was given to the prolonged ethmoid bone referred by Sir Philip Egerton to *Saurocephalus lanciformis*, as then understood.

In that paper Dr. Leidy proves that the teeth assigned by Agassiz to the *Saurocephalus* of Harlan, had no relation to that genus, and he refers the jaws and teeth from the English chalk to a new genus under the name of *Protosphyrapna*, Leidy. The "rostral" bones described by Sir Philip Egerton, he contended, did not belong to *Protosphyrapna*, but to a species of *Xiphias*, to which he gave the trivial name of *X. Dixoni*. Subsequently Professor Cope described his genus *Erisichthe*, which certainly embodies both of Leidy's species. I may mention here that the prolonged ethmoids are found in our Chalk, Upper Greensand, and Gault; and here also are found (and in no other deposit) the peculiar fin-rays referred to *Ptychodus* by Agassiz. From this association the inference is natural that the ethmoids and fins belong to the same species of fish, viz, the *Protosphyrapna* of Leidy, *Erisichthe* Cope. (See Paper by W. Davies, F. G. S., on *Saurocephalus lanciformis* of the British Crustaceous Deposits, with description of a new species. (Geol. Mag., 1878, Decade II, vol. V, p. 254, pl. viii.)

DAVIES, W. M. Brief notices of the papers read before the Geological Section of the American Association: Tully Limestone, by S. G. Williams; Mollusca of the New Jersey Marls, by R. P. Whitfield; New York Devonian Geology, by H. S. Williams; Cambrian in New York, by C. D. Walcott; Cretaceous Flora, Devonian and Carboniferous, Fishes, by J. S. Newberry (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 319-324, October, 1886. New Haven.)

DAWSON, J. W., Sir. Cretaceous Floras of the Northwest. Canad. Rec. Sci., vol. II, No. 1, pp. 1-9, 1886. Montreal.

A summary of the article in the Transactions of the Royal Society of Canada.

DAWSON, J. W., Sir. Cretaceous of Northwestern Canada. (Canad. Rec. Sci.; Amer. Jour. Sci., 3d ser., vol. XXXI, p. 155, February, 1886. New Haven.)

Notice of.

DAWSON, J. W., Sir. The Fossil Flora of the western Northwest Territory of Canada. (Amer. Nat., vol. XX, pp. 157, 158, February, 1886. New Haven.)

Brief résumé of papers noticed last year.

DAWSON, J. W., Sir. On the Fossil Flora of the Laramie Series of Western Canada. (Amer. Nat., vol. XX, pp. 635-637, July, 1886. Philadelphia.)

Abstract of a paper read before the Royal Society of Canada, May, 1886, by Sir J. W. Dawson, LL.D., F. R. S.

DAWSON, J. W., Sir. On the Fossil Flora of the Laramie Series of Western Canada. Abstract of a paper read to Royal Society of Canada, May, 1886. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 242, 243, September, 1885. New Haven.)

DAWSON, J. W., Sir. On Canadian Examples of Supposed Fossil Algæ. (Geol. Mag., new ser., Decade III, vol. III, pp. 503, 504, November, 1886. London.)

Notice or abstract of a paper read before the British Association for the Advancement of Science, Birmingham, September, 1886. Section C (Geology).

DAWSON, J. W., Sir. (See Grant, C. E.; Weiss, Ernst.)

DOLLO. (See Lydekker, R.)

DWIGHT, WILLIAM B. Recent Explorations in the Wappinger Valley Limestone of Dutchess County, New York. No. 5. Discovery of fossiliferous Potsdam strata at Poughkeepsie, New York (illustrated by a map, plate vi). (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 125-133, February, 1886. New Haven.)

Gives a list of the fossils found, and mentions a new species of *Ptychoparia* (*Conocephalites*), resembling the *Iowensis*, but possessing an occipital spine.

DWIGHT, WILLIAM B. Discovery of fossiliferous Potsdam strata at Poughkeepsie, New York. (Proc. A. A. A. S., vol. XXXIV, pt. 1, pp. 204-209, 1886. Salem.)

Describes a ledge rich in Potsdam fossils about one mile southwest of Vassar College; describes the stratigraphic relations, and gives a preliminary list of the species found.

DWIGHT, W. B. (See Ford, S. W.; Hinde, George J.)

ELLIS, R. W. Report on the geological formations of eastern Albert and Westmoreland Counties, New Brunswick, and of portions of Cumberland and Colchester Counties, Nova Scotia, embracing the Spring Hill Coal Basin and the Carboniferous System north of the Cobequid Mountains. 1884. (Geol. and Nat. Hist. Surv. Canada, Ann. Rep., new ser., vol. I, pp. 1e-71e, 1886. Montreal.)

Mentions fossil plants, which, while presenting some of the features of Millstone grit plants, are from their stratigraphical position without doubt older, and probably indicate a portion of the Lower Carboniferous formation; these occur near Delaney Settlement. Gives a short list of Clinton fossils determined by Mr. H. M. Ami, from Wentworth station, and cites the list determined by the late Mr. Billings from the same place.

ETHERIDGE, ROBERT, Jr., and P. HERBERT CARPENTER. Catalogue of the Blastoidea in the geological department of the British Museum (Natural History), with an account of the morphology and systematic position of the group, and a revision of the genera and species. Illustrated by twenty lithographic plates, etc. pp. I-XVI and 1-322, figs. 1-8, pls. I-XX, 1886. London.

Contains: Morphology.—The zoological history of the Blastoidea; the stem and calyx; the ambulacra; the summit-plates; the hydrospires and spiracles; the zoological characters of the Blastoidea.

Distribution.—The geological and geographical distribution of the Blastoidea; table showing the distribution of the genera of the Blastoidea in space and time; a stratigraphical list of all known Blastoids arranged geographically.

Classification.—Description of the species.—Bibliography.

Classification.

Class Blastoidea.

## ETHERIDGE, ROBERT, JR., and P. HERBERT CARPENTER—Continued.

Order Regulares, E. and C., 1886.

(1) Family *Pentremitidæ*, D'Orbigny, 1852 (Emend. E. & C., 1886).

(2) Family *Troostoblastidæ*, E. & C., 1886.

(3) Family *Nucleoblastidæ*, E. & C., 1886.

I. Subfamily *Elæocrinidæ*, E. & C., 1886.

II. Subfamily *Schizoblastoidæ*, E. & C., 1886.

(4) Family *Granatoblastidæ*, E. & C., 1886.

(5) Family *Codasteridæ*, E. & C., 1886.

I. Subfamily *Phænoschismidæ*, E. & C., 1886.

II. Subfamily *Cryptoschismidæ*, E. & C., 1886.

Order Irregulares, E. & C., 1886.

(6) Family *Astrocrinitidæ*, T. & T. Austin, 1843 (Emend. E. & C., 1886).

I. Basals unsymmetrical.

II. Basals symmetrical; odd ambalacrum linear.

The following is an attempt at an abstract of the work on American forms :

Regulares, E. & C., 1886.

*Pentremitidæ*, D'Orbigny, 1852 (Emend. E. & C., 1886).

*Pentremites*, Say, 1820 (Emend. E. & C., 1886), type.

*Enerina Godoni*, De France. This genus as restricted is essentially Carboniferous and strictly American, with one possible exception, *P. ovalis*, Goldfuss.

*P. Godoni*, var. *major*, var. nov.

*Pentremitidæ*, D'Orbigny, 1849 (Emend. E. & C., 1886). Type *Pentremites Palletti*, de Verneuil. This genus is limited to the Devonian Period, and in America to the Hamilton Group, which contains at least two, and perhaps six, species.

*Mesoblastus*,\* gen. nov. Type *Pentremites crenulatus*, Roemer. This is essentially a Carboniferous genus, and occurs on both sides of the Atlantic. The authors think it probable that *Granatocrinus glaber*, M. & W., should be referred to this group, and also some other American species, hitherto described under *Granatocrinus*.

*Troostoblastidæ*, E. & C., 1886.

*Troostocrinus*, F. B. Shumard, 1865 (Emend. E. & C., 1886).

Type *Pentremites Reinwardtii*, Troost. The type species is characteristic of the Niagara Period of America. No Devonian species are known, but if, as the authors suspect, *P. Grosvenori*, Shumard, be referable to this genus, it reappeared in the upper strata of the American Carboniferous limestone.

*Metablastus*, gen. nov. Type *Pentremites lineatus*, Shumard. The authors refer doubtfully to this genus, *Pentremites subcylindricus*, Hall, and *Codaster pentalobus*, Hall, from the Niagara group; most of the forms are from the American Carboniferous system. The type series occurs in the Upper Burlington limestone, two are found in the Keokuk and two more in the Warsaw limestone, though none are known in the Kaskaskia limestone, so rich in *Pentremites*.

*Tricælocrinus*, Meek & Worthen, 1868. Type *Pentremites Woodmani*, Meek & Worthen. This is an essentially Carboniferous type, and, so far as we at present know, it is limited to the Keokuk and St. Louis groups of the American Carboniferous system; four species are known, though it is probable that two of them are identical. *Tricælocrinus Meekianus*, sp. nov., Warsaw limestone, Spurgen Hill, Indiana.

*Nucleoblastidæ*, E. & C., 1886.

I. Subfamily *Elæocrinidæ*, E. & C., 1886.

\* Μέσος, intermediate.

## ETHERIDGE, ROBERT, JR., and P. HERBERT CARPENTER—Continued.

*Elæacrinus*, F. Roemer, 1851 (Emend. Hall, 1862). Type *Pentremites Verneuli*, Troost. This is purely a Devonian genus, and appears to be generally distributed throughout that formation in the United States and Canada, but is unknown in rocks of a similar age in Europe. There appear to be no species common to the Lower and Upper Devonian. *Elæacrinus Verneuli*, var. *pomum*, var. nov., Columbus, Ohio; Corniferous limestone, Clarke County, Indiana; Upper Helderberg group, Lower Devonian.

*Elæacrinus* sp.?

II. Subfamily *Schizoblastidæ*, E. & C., 1886.

*Schizoblastus*, E. & C., 1882. Type *Pentremites Sayi*, Shumard. *S. melonoides* and *S. Sayi* are limited to the Burlington group. These would be the earliest species of the genus, unless the *Pentremites Sampsoni* of Hambach form the underlying Chouteau limestone, or Shumard's *P. Missouriensis* should prove to be a *Schizoblastus*. The authors know of no species of it above the Burlington limestone, with the possible exception of *Granatocrinus granulatus*, M. & W., which occurs in the Keokuk limestone of Indiana and Illinois. Only four species are recognized as belonging certainly to this group, though eight others, it is thought, may belong to it.

*Cryptoblastus*, gen. nov. Type *Pentremites melo*, Owen & Shumard. The genus is exclusively confined to the Subcarboniferous of America, three species belonging to the Burlington limestone and one to the St. Louis; but four species are recognized.

*Granatoblastidæ*, E. & C., 1886. *Granatocrinus* (Troost, 1849; Hall, 1862) (Emend. E. & C., 1882). Type *Pentremites Norwoodi*, Owen & Shumard. Of the sixteen species which have been described in America *G. Norwoodi*, the type of the genus, is the only one which they can with any certainty refer to this genus; it occurs in the Burlington limestone. The genus, as now defined, is strictly limited to rocks of Carboniferous age.

*Heteroblastus*,\* gen. nov. Type *H. Cumberlandi*, sp. nov. ? *Pentremites cornutus*, M. & W., St. Louis limestone, is the only American species referred to this genus.

*Codasteridæ*, E. & C., 1886.

I. Subfamily *Phænoschismidæ*, E. & C., 1886.

*Codaster*, McCoy, 1849. Type *Codaster trilobatus*, McCoy.

The authors are prepared to admit five or perhaps nine species of *Codaster* though not more, on account of the indefinite manner in which certain so-called Codasters have been described and figured. In Britain there is only one *C. trilobatus*, the type. The American species differ from the British type in possessing a more elongate form, greater convexity of summit, a narrow base, and more complex ambulacra. Four of these are well defined, viz: *C. alternatus*, *C. gracilis*, *C. Hindei*, and *C. pyramidatus*. Doubtful species are: *C. Americanus*, *C. pulchellus*, *C. Whitei*, and *Pentremites subtruncatus*. If *C. pulchellus*, Miller & Dyer, from the Niagara group be rightly so named, this genus has the most extended geological range of all the Blastoidea. Commencing in the Upper Silurian of America, it is well represented both in the Upper Helderberg and in the Hamilton group, of the Devonian, especially the latter; while the doubtful *C. Whitei*, Hall, occurs in the transition bed between the Upper Burlington and the Keokuk of the Subcarboniferous. The type species (*C. trilobatus*) is fairly abundant in the Carboniferous limestone of Lancashire and Yorkshire, and may be considered, they suppose, as the last survivor of the genus.

\* "Ετερος, unusual.



## ETHERIDGE, ROBERT, JR., and P. HERBERT CARPENTER—Continued.

*Phanoscisma*, E. & C., 1832. Type *Pentatrematites acuta*, G. B. Sby. There appear to be three species in the Carboniferous rocks of America. ? *Pentremites* (*Codaster*) *Kentuckiensis*, Shumard, and two species from New Mexico which Mr. Wachsmuth will describe.

II. Subfamily *Cryptoscismida*, E. & C., 1886.

*Orophocrinus*, von Seebach, 1864. Type *Pentremites stelliformis*, Owen and Shumard. Three American species are referred to this genus, all confined to rocks of the Carboniferous period—*Codonites campanulatus*, Hambach, *C. gracilis*, M. & W., and the type species. The genus occurs in rocks of the same age in England, Ireland and Belgium.

Order Irregulares, E. & C., 1886.

This order has been established to contain three very remarkable genera: *Eleutheroocrinus* of Shumard & Yandell, two species of which occur in the Devonian rocks of America, and the British genera *Astrocrinites* and *Pentephyllum*.

*Astrocrinitidae*, T. & T. Austin, 1843 (Emend. E. & C.). This family is divided into two groups. The first contains *Eleutheroocrinus* and *Astrocrinites*, T. & T. Austin; the second *Pentephyllum*, Haughton.

ETHERIDGE, ROBERT, jr., and P. HERBERT CARPENTER. Catalogue of the Blastoidea in the Geological Department of the British Museum (Natural History), with an Account of the Morphology and Systematic Position of the Group, and a Revision of the Genera and Species; pp. i-xiv and 1-322. Illustrated by twenty lithographic plates and twelve wood-cuts. (London, 1886. Printed by order of the Trustees.) Price 25s. Geol. Mag., new ser., Decade III, vol. III, pp. 419-425, figs. 1-3. September, 1886. London.)

Review of, contains many remarks on American species.

ETHERIDGE, ROBERT, jr., and P. HERBERT CARPENTER. Catalogue of the Blastoidea in the Geological Department of the British Museum, 322 pp., 4to, with 20 plates. London, 1886. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 409-410. November, 1886. New Haven.)

Review of.

ETHERIDGE, ROBERT, jr., and P. HERBERT CARPENTER. Catalogue of the Blastoidea in the Geological Department of the British Museum (Natural History), with an Account of the Morphology and Systematic Position of the Group, and a Revision of the Genera and Species; pp. i-xvi and 1-322; 20 plates. London: Printed by order of the Trustees, 1886. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVIII, pp. 412-417. November, 1886. London.)

Review and abstract of.

"The description of the various species of Blastoids is very limited both in space and time. A few species appear to be common to the Upper and Lower Devonian of America, but each of the great divisions of the Sub-carboniferous in the Mississippi Valley seems to have its own particular types. No Blastoid occurs on both sides of the Atlantic; one species is common to the Devonian of Spain and Germany, and another to the Carboniferous limestone of Britain and Belgium. But, with these exceptions, the range of individual specific types is very limited indeed."

EYERMAN, JOHN. Footprints on the Triassic Sandstone (Jura-Trias) of New Jersey. (Am. Jour. Sci., 3d ser., vol. xxxi, p. 72. January, 1886. New Haven.)

Related to *Anomæpus major* of Hitchcock, in size and characters. From near Milford, Hunterdon County, New Jersey.

FABER, CHARLES L. Remarks on some fossils of the Cincinnati group. (Jour. Cincinnati Soc. Nat. Hist., vol. ix, pp. 14-20, Pl. i. April, 1886. Cincinnati.)

Describes the new genus *Lepidocoleus* as distinct from *Plumulites*, Barrande, with *L. Jamesi* (Hall & Whitfield), Faber as the type. Describes also the new species: *Cyclocystoides nitidus*, *Cyrtoceras tenuiseptum*, and gives a description of the genus *Merocrinus*, Walcott, and *Merocrinus curtus* (Ulrich), Faber.

FILHOL, H. Observations sur le mémoire de M. Cope intitulé relations des horizons renfermant des débris d'animaux vertébrés fossiles en Europe et en Amérique. (Ann. Sci. Geol., vol. xvii, pp. 1-16. Adenda. Pl. vi., 1885. Paris.)

Considers that *Anaptomorphus* and *Necrolemur*, which Mr. Cope had thought might be identical, although evidently belonging to the same group of Lemuroids, are too different to be joined zoologically under the same name.

Mr. Cope says "that the *Hyrachius* is the American *Lophiodon*, for there are only slight differences between them; both exist in France, the second in the lower Parisian, the first in the Phosphorites." The present author thinks it probable that the *Hyrachius*, animals descending from the *Lophiodon*, lived both on the old and new continent and were represented in France by four species, *H. priscus*, *H. Donvillei*, *H. Zeillerei*, and *H. intermedius*.

Future discoveries will enable us to understand the changes effected in the *Hyrachius*, which must have modified themselves progressively to give birth to the Tapirs.

FORD, S. W. Notice of a new genus of Lower Silurian Brachiopoda. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 466, 467, Figs. 1, 2. June, 1886. New Haven.)

Describes the new genus *Billingsia*, of which *Obolella desiderata*, Billings, is the type.

FORD, S. W. Notice of a new genus of Lower Silurian Brachiopoda. (Nature, vol. xxxiv, p. 208, 1886. London and New York.)

Notice of. See Amer. Jour. Sci., June. *Billingsia*.

FORD, S. W. Note on the recently proposed genus *Billingsia*. (Amer. Jour. Sci., 3d ser., vol. xxxii, p. 325, October, 1886. New Haven.)

Substitutes the name *Elkania*, based upon Mr. Billings's Christian name Elkanah, to *Billingsia*, preoccupied by de Koninck.

FORD, S. W., and W. B. DWIGHT. Preliminary Report of S. W. Ford and W. B. Dwight upon fossils obtained in 1885 from Metamorphic limestones of the Taconic Series of Emmons, at Canaan, New York.

A. Explanatory statements with reference to the paleontological investigations at Canaan, New York, by W. B. Dwight.

B. Joint Report on the Fossils. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 248-255, pl. vii, April, 1886. New Haven.)

Proposes the new species *Cleiocrinus Billingsi*. Considers the fossils as of Trenton age.

FORD, S. W., and W. B. DWIGHT. Preliminary Report of S. W. Ford and W. B. Dwight upon the fossils obtained in 1885 from Metamorphic limestones of the Taconic series of Prof. Emmons at Canaan, New York. (With plate vii.)

A. Explanatory statement with reference to the paleontological investigations at Canaan, by W. B. Dwight. (Nature, vol. xxxiv, p. 63, 1886. London and New York.)

Notice of. See Amer. Jour. Sci., April.

FORD, S. W. Note on the Age of the Swedish Paradoxides Beds. (Amer. Jour. Sci., 3d ser., vol. xxxii, pp. 473-476, December, 1886. New Haven.)

The facts (1) that the position of *Paradoxides Kjerulfi* in the Swedish Primordial is directly below the zone carrying the British *P. Hicksi*; (2) that it is clearly allied to *P. ölandicus*, a Brachypleural species and an undoubted *Paradoxides*; and (3) that it is a Menevian species in America; all appear to me to indicate that it is a Menevian species in Europe also, and that, the strata there affording it, may be regarded as constituting a legitimate portion of the Swedish Paradoxides measures.

FORD, S. W. (See Hinde, George J.)

FOERSTE, A. F. The Clinton Group of Ohio. (Bull. Sci. Laboratories Denison University, vol. I, pp. 63-120, pls. xiii, xiv, December, 1885. Granville, Ohio.)

Paleontology (pp. 76-120) describes the fossils of the group and discusses their stratigraphic relations. The following new species are described: *Leptæna prolongata*, *Orthis fausta*, *O. daytonensis*, *O. triplesia* (generic relations unknown), *Grammysia caswelli*, *Nucula minima*, *Trochonema nana*, *Raphistoma affinis*, *Cyclora alta*, *Bucania exigua*, *Bellerophon fiscello-striatus*, *Illenus ambiguus*, *Dalmanites werthneri*, and *Orthoceras inceptum*.

GARDNER, J. S. Sketch of the early history and subsequent progress of Paleobotany. (Nature, vol. xxxiv, pp. 598-599, 1886. London and New York.)

From the Fifth Annual Report of the U. S. Geological Survey, by Lester F. Ward, condensed by J. S. Gardner.

GARDNER, J. S. Mesozoic Angiosperms. (Plate ix, Geol. Mag., new ser., Decade III, vol. III, pp. 342-345, August, 1886. London.)

Review and abstract of Prof. Lester F. Ward's article on "Paleobotany" in the Fifth Annual Report of the U. S. Geological Survey.

GEYLER, HERMANN T. Leo Lesquereux Contributions to the fossil flora of the Western Territories. Part III. The Cretaceous and Tertiary floras. In F. V. Hayden's Report of the United States Geological Survey of the Territories, vol. VIII. (283 Seiten und 59 Tafeln, 4to. Neu. Jahrb. Min. Geol. und Pal., 1886, Band I, pp. 153-159. Stuttgart.)

Abstract.

GRANT, C. E., and W. DAWSON. Notes on Pleistocene Fossils from Anticosti. (Canad. Rec. Sci., vol. II, No. 1, pp. 44-48, 1886. Montreal.)

Gives lists of the fossils, all of which occur also as living species in the colder waters of the Gulf and River St. Lawrence.

GRATACAP, L. P. Fish remains and tracks in the Triassic rocks at Weehawken, N. J. (Amer. Nat., vol. xx, pp. 243-246, pls. xii, xiii, figs. pp. 244 and 246, March, 1886. Philadelphia.)

Describes their occurrence.

GRATACAP, L. P. Fossil fish in New Jersey Trias. Pop. Sci. Monthly, vol. xxix, p. 574, August, 1886. New York.)

Notice of a notice in the American Naturalist of fossil fish (*Palæoniscus latus* ?) and other remains near Weehawken.

HALL, JAMES. Paleontology of New York. Vol. v, part II, Lamelli-branchiata. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 311, 312, April, 1886. New Haven.)

Notice of the contents of.

HALL, JAMES. Bryozoa of the Upper Helderberg Group. Plates and explanations. Published in advance of the Report of the State Geologist for 1886, and of vol. VI. (Pal. N. Y., 1886, pls. i-xii, pp. 1-29, 1886. Albany.)

This interesting and valuable work contains many new species which are represented in the plates by beautiful figures. They are as follows: Plate xxv: *Callopora geniculata*, *Trematella glomerata*, *Acanthoclema alternata*, *Tropidopora nana*, *Nemataxis fibrosa*. Plate xxvii: *Stictopora rectilatera*, *S. vermícula*, *S. crescens*. Plate xlii: *Fenestella diaphana*, *F. sinuosa*. Plate xlv *Fenestella tenella*, *F. crebescens*.

The new genera and subgenera which appear among the above are: *Trematella*, *Acanthoclema*, *Coscinostrya*, *Lichenalia* (*Pileotrypa*, nov. s. g.), *L.* (*Odontotrypa*, nov. s. g.).

HALL, JAMES. (See Williams, Henry S.)

HAMILTON ASSOCIATION. Report of Geological Section of the Hamilton Association. Read at annual meeting, May, 1885. (Jour. and Proc. Hamilton Assoc., 1884-'85, vol. I, pt. 2, pp. 83-89, 1885. Hamilton, Ontario.)

Gives a list of fossils presented to the Association.

HARVEY, F. L. On *Anthracomartus trilobitus*, Scudder. (Proc. Acad. Nat. Sci., Phila., vol. —, pp. 231, 232, September, 1886. Philadelphia.)

Some account of this interesting species which occurs at the base of the coal measures in Washington County in northwestern Arkansas.

HEILPRIN, ANGELO. Contributions to the Tertiary Geology and Paleontology of the United States. Published by the author, 1886, pp. 117. (Pop. Sci. Monthly, vol. xxix, p. 107, September, 1886. New York.)

Notice of.

HEILPRIN, ANGELO. Notes on the Tertiary Geology and Paleontology of the United States. (Proc. Acad. Nat. Sci., vol. —, pp. 57, 58, March, 1886. Philadelphia.)

Contains a list of Eocene fossils from the northern border of San Augustine County, Texas; the horizon represented is the Claibornian.

Mentions receiving specimens of *Orbitoides* and of *Nummulites floridanus*, Heilprin, from a locality 6 miles northwest of Gainesville, Florida; this represents



## HEILPRIN, ANGELO—Continued.

the most northern locality in the State where the members of the group of Foraminifera have been found. He also received from approximately the same locality Arredonda, Alachua County, specimens containing *Nummulites floridanus*, *Orbitoides*, and *Operculina rotella* (*O. complanata*?).

Some marine Eocene fossils from the neighborhood of Paducah, Kentucky, have also been received, and a list of the genera is given; the horizon is considered to be that of the older Tertiaries of Maryland and Virginia.

HEILPRIN, ANGELO. Explorations on the West Coast of Florida and in the Okeechobee Wilderness, with Special Reference to the Geology and Zoology of the Floridan Peninsula. A Narrative of Researches undertaken under the Auspices of the Wagner Free Institute of Science of Philadelphia. (Trans. Wagner Free Institute Sci., vol. —, pp. 65–127, 1886. Philadelphia.)

The author concludes that there is not a particle of evidence sustaining the coral theory of growth of the peninsula. The formations represented in the State are the Oligocene, Miocene, Pliocene, and Post-Pliocene, which follow each other in regular succession, beginning with the oldest, from the north to the south, thus clearly indicating the direction of growth of the peninsula. No indisputable Eocene rocks have thus far been identified in the State, but not improbably some such exist in the more northerly sections, and possibly include even a part of what has generally been referred to the Oligocene. Fresh-water streams, and consequently, dry land, existed in the more southern parts of the peninsula during the Pliocene period, as is proved by the interassociation of marine and fluviatile mollusks in the deposits of the Caloosahatchie. The modern fauna of the coast is indisputably a derivative, through successive evolutionary changes of the pre-existing faunas of the Pliocene and Miocene periods of the same region, and the immediate ancestors of many of the living forms, but slightly differing in specific characters, can be determined among the Pliocene fossils of the Caloosahatchie. The doctrine of evolution thus receives positive and most striking confirmation from the past invertebrate fauna of the Floridan region.

Man's great antiquity on the peninsula is established beyond a doubt, and not improbably the fossilized remains found on Sarasota Bay, now wholly converted into limonite, represent the most ancient belongings of man that have ever been discovered.

Fossils of the Pliocene ("Floridian") formation of the Caloosahatchie. Among these the following new species are described: *Fusus Caloosaensis*, *Fasciolaria scalarina*, *Melongena subcoronata*, *Fulgur rupum*, *Turbinella regina*, *Vasum horridum*, *Mezzalina bulbosa*, *Voluta Floridana*, *Mitra lineolata*, *Columbella rusticoides*, *Comus Tryoni*, *Strombus Leidyi*, *Cypræa (Siphocypræa) problematica*, *Turritella peratenuata*, *T. apicalis*, *T. cingulata*, *T. modiosulcata*, *T. subannulata*, *Cerithium ornatisimum*, *Panopæa cymbula*, *P. Floridana*, *P. navicula*, *Semele perlamellosa*, *Venus rugatina*, *Cardium Floridanum*, *Hemicardium columba*, *Chama crassa*, *Lucina disciformis*, *Arca scalarina*, *A. crassicauda*, *A. aquila*, *A. (Arcoptera) aviculariformis*, *Spondylus rotundatus*, *Astræa meridionalis*.

Author gives list of species found in the deposits of the Caloosahatchie.

Fossils of the Silex-bearing Marl (Miocene) of Ballast Point, Hillsboro Bay: *Wagneria pugnax*, *Murex larvacosta*, *M. crispangula*, *M. tritonopsis*, *M. trophoniformis*, *M. spinulosa*, *Latirus Floridanus*, *Turbinella polygonata*, *Vasum subcapitellum*, *Voluta musicina*, *V. (Lyria) zebra*, *Mitra (conomitra) angulata*,

## HEILPRIN, ANGELO—Continued.

*Conus planiceps*, *Cypræa tumulus*, *Natica amphora*, *N. streptostoma*, *Turritella pagodaformis*, *T. Tampæ*, *Turbo crenorugatus*, *T. heliciformis*, *Delphinula* (?) *solariella*, *Pseudotrochus turbinatus*, *Cerithium præcursor*, *Pyrazisinus campanulatus*, *Partula Americana*, *Cytherca nuciformis*, *Lucina Hillsboroensis*, *Crassatella deformis*, *Cardita* (*Carditamera*) *serricosta*, *Arca* (sic) *arcula*, *Leda flexuosa*.

Author gives list of species occurring in the Miocene deposits of Ballast Point, Hillsboro Bay.

Fossils from localities north of Ballast Point: *Cerithium Hillsboroensis*, *C. cornutum*.

HEILPRIN, ANGELO. On Miocene Fossils from southern New Jersey. (Proc. Acad. Nat. Sci. Philad., vol. —, p. 351, December, 1886. Philadelphia.)

Gives a list of forms found near Bridgeton and Jericho, Cumberland County, New Jersey, from the Lower Atlantic Miocene Marylandian series.

HEILPRIN, ANGELO. (See Ashburner, Charles A.; Kayser; Steinmann. HICKS, L. E. The Permian in Nebraska. (Amer. Nat., vol. xx, pp. 881–883, October, 1886. Philadelphia.)

Refers provisionally to this period a group of strata found along the valley of the Blue River in Gage County. Mentions a gigantic *Pinna* and a fine cephalopod intermediate between *Nautilus* and *Ammonites*, and says that besides the presence of types undoubtedly new and approximating Mesozoic forms, the great diminution of typical Carboniferous species is noteworthy. Of one hundred and twenty-three species enumerated by Meek from the coal measures along the Missouri River in Nebraska, not more than a dozen run up into the Permian. There are some indications of unconformity between the coal measures and the Permian, but further investigation is required on this point.

HILGARD, E. W. Dr. Otto Meyer and the southwestern Tertiary. (Science, vol. VII, No. 152, p. 11, January, 1886. New York.)

A criticism of Dr. Meyer's reply to his critics, published in the American Journal of Science for December, 1885.

HILGARD, E. W. Making deposits of the remains of birds, squirrels, and other small animals. Williams's Mineral Resources of the United States for the years 1883 and 1884, p. 940. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 398, 399, May, 1886. New Haven.)

Abstract of.

HILL, FRANKLIN C. On the mounting of fossils. (Amer. Nat., vol. xx, pp. 353–359, figs. 1–8, April, 1886. Philadelphia.)

Describes methods of cleaning, mending, and mounting fossils for exhibition.

HINDE, GEORGE JENNINGS. A Monograph of the British Stromatoporoidea, by H. Alleyne Nicholson. Part I. General Introduction, pp. iii, and 130, with 11 plates. Paleontographical Society, volume for 1885. (Geol. Mag., new ser., Decade III, vol. III, pp. 123–128, March, 1886. London.)

Review and abstract of. *Beatricea*, Billings is included among the Stromatoporoidea.

HINDE, GEORGE JENNINGS. *Hystriocrinus*, *Hinde versus Arthroacantha*, Williams; a Question of Nomenclature. (Ann. & Mag. Nat. Hist., pp. 271-289, March, 1886.)

Defends the use of his term *Hystriocrinus* and considers *Arthroacantha*, Williams, as a synonym of it.

HINDE, GEORGE JENNINGS. Report on the Invertebrata of the Laramie and Cretaceous Rocks of the Northwest Territory. Contributions to Canadian Paleontology, by J. F. Whiteaves. Vol. I, pt. 1, 8vo., pp. 89, and 6 plates; Montreal, Dawson Bros., 1885. (Geol. Mag., new ser., Decade III, vol. III, p. 129, March, 1886. London.)

Review and abstract of.

HINDE, GEORGE JENNINGS. Bulletins of the United States Geological Survey, Nos. 1-19; Government Printing Office, Washington, 1884-'85. (Geol. Mag., new ser., Decade III, vol. III, pp. 172, 173, April, 1886. London.)

Mentions the following on paleontologic matters: "On Mesozoic Fossils," by Dr. C. A. White, who also contributes papers "On the Mesozoic and Cenozoic Palæontology of California," and "On Marine Eocene, Freshwater Miocene, and other Fossil Mollusca of Western North America;" "On the fossil Faunas of the Upper Devonian along the Meridian of 76, 30," by Prof. H. S. Williams; "On the Cambrian Faunas of North America," by C. D. Walcott; "On the Quaternary and Recent Mollusca of the Great Basin," by R. E. Call; and "On the higher Devonian Faunas of Ontario County, New York," by J. M. Clarke.

HINDE, GEORGE JENNINGS. Emmons's Original Taconic Series.

- I. On Lower Silurian Fossils from a Limestone of the Original Taconic of Emmons, by J. D. Dana.
- II. Preliminary Report of S. W. Ford and W. B. Dwight upon Fossils obtained in 1885 from Metamorphic Limestones of the Taconic Series of Emmons, at Canaan, New York. Amer. Jour. Sci., vol. XXXI, pp. 241-253, pl. VII, April, 1886. (Geol. Mag., new ser., Decade III, vol. III, pp. 277, June, 1886. London.)

Notices and brief abstracts of these memoirs.

HOLLICK (ARTHUR). Remarks on some fossil leaves from Kreischerville and New Jersey. (Proc. Nat. Sci. Assoc., Staten Island, February 13, 1886. New Brighton.)

The examination of these fossils confirms the fact that the Kreischerville beds are but the extension of those at Woodbridge and Amboy and were continuous with them until cut through in comparatively recent times by the channel of the Kills. (Cretaceous age.)

HYATT, ALPHEUS. Larval Theory of the Origin of Tissue. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 332-347, May, 1886. New Haven.)

Abstract of a paper with the same title published in Proc. Bost. Soc. Nat. Hist., vol. XXIII, 1884, pp. 45-163, and has in addition the suggestion that *Folvoa* and *Eudorina* are true intermediate forms entitled to be called Mesozoa, or Blastrea. (See last year's record.)

HYATT, ALPHEUS. Larval Theory of the Origin of Tissue. (Ann. & Mag. Nat. Hist., 5th ser., vol. XVIII, pp. 193-209, September, 1886. London.)

## HYATT, ALPHEUS—Continued.

From the American Journal of Science for May, 1886, pp. 332-347. This article is an abstract of a paper with the same title published in Proc. Boston Soc. Nat. Hist., vol. XXIII, 1884, pp. 45-163, but has in addition the suggestion that *Volvox* and *Eudorina* are true intermediate forms entitled to be called Mesozoa or Blastrea.

HYATT, ALPHEUS. Larval Theory of the Origin of Tissue. (Nature, vol. XXXIV, p. 158, 1886. London and New York.)

Notice of.

See American Journal of Science, May.

JACKSON, ROBERT T. A new museum pest. (Science, vol. VII, No. 173, pp. 481-483, May, 1886. New York.)

A description of a museum pest which injured and destroyed many of the labels used in a collection to illustrate a course in paleontology at the museum of comparative zoology in Cambridge.

JAMES, JOSEPH F. Cephalopoda of the Cincinnati group. (Jour. Cin. Soc. Nat. Hist., vol. VIII, pp. 235-253, pl. IV, January, 1886. Cincinnati.)

The present paper is offered as a contribution toward the complete collection of descriptions of the fossils of the Cincinnati group. At the close of it will be found a brief bibliography of the works referred to. Describes the new species *Colpoceras arcuatum* and *Cyrtoceras Faberi*.

JAMES, JOSEPH F. Description of a new species of Gomphoceras from the Trenton of Wisconsin. (Jour. Cin. Soc. Nat. Hist., vol. VIII, p. 255, pl. IV, fig. 2, January, 1886. Cincinnati.)

Describes *Gomphoceras Powersi*.

JAMES, JOSEPH F. Note on a recent synonym in the Palæontology of the Cincinnati group. (Jour. Cin. Soc. Nat. Hist., vol. IX, pp. 39, July, 1886. Cincinnati.)

Considers that *Labechia montifera*, Ulrich, "Contributions to American Palæontology," May, 1886, is a synonym of *Stromatopora subcylindrica*. U. P. James in Jour. Cin. Soc. Nat. Hist., April, 1884.

JONES, T. RUPERT. On Some Fossil Ostracoda from Colorado. (Geol. Mag., new ser., Decade III, vol. III, pp. 145-148, pl. IV, April, 1888. London.)

Describes some Ostracoda from the Jurassic Atlantosarus beds near Cañon City, Colorado, sent to him by Dr. C. A. White.

He describes the following new species: *Metacypris Bradyi*, *M. Whitei*, *Cytherideis Marshii*, *Cytheridea atlantosaurica*.

JONES, T. RUPERT. Fossil Ostracoda from Colorado. (Geol. Mag., April; Amer. Jour. Sci., 3d ser., vol. XXXI, p. 404, May, 1886. New Haven.)

Notice of contents of.

JONES, T. RUPERT. On Palæozoic Phyllopora. (Geol. Mag., new ser. Decade III, vol. III, pp. 456-462, October, 1886. London.)

A perfect specimen of *Ceratiocaris acuminata*, Hall, has been lately described and figured by Dr. Julius Pohlman in the Bulletin of the Buffalo Society of Natural Science, vol. V, No. 1, 1886, pp. 28-29, pl. III, fig. 2, p. 457.



## JONES, T. RUPPERT—Continued.

Dr. A. S. Packard, jr., has described and figured some peculiar appearances on an internal cast of a Carboniferous Phyllopodous carapace from Illinois, as traces of four pairs of lamellate limbs (thoracic feet) probably "homologues of the exopodites of Nebalia." He has defined the genus and species as *Cryptozoa problematica*. (Amer. Nat. Extra, February, 1886, p. 156; and Proc. Amer. Philos. Soc., vol. xxiii, No. 123, pp. 380-383) p. 462.

In a Geological Report, Assembly Document No. 161, 1885 (or 1886), Mr. J. M. Clarke has defined the localities and geological succession in Ontario County, New York, where the Phyllopods which he previously described (see Second Report, 1884, pp. 80-86, and "Third Report," p. 3), have occurred with or without Goniatites (p. 462).

## JONES, S. RUPERT. (See Dames.)

KAYSER. (Review.) Henry S. Williams: On the Fossil Faunas of the Upper Devonian, along the meridian  $76^{\circ} 80'$ , from Tompkins County, New York, to Bradford County, Pennsylvania. Bull. U. S. Geol. Survey, No. 3, 1884. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band I, pp. 322, 323. Stuttgart.)

Abstract.

KAYSER. (Review.) A. Heilprin: On a Carboniferous Ammonite from Texas. Proc. Acad. Nat. Sci., Phila., 1884. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band I, p. 480. Stuttgart.)

Abstract.

KAYSER. (Review.) J. M. Clarke: On the Higher Devonian Faunas of Ontario County. Mit 3 palæont. Tafeln. Bull. U. S. Geol. Survey, No. 16, 1885. (Neu. Jahrb. Min., Geol., u. Pal., 1886, Band I, pp. 480, 481. Stuttgart.)

Abstract.

KAYSER. (Review.) C. D. Walcott: Palæontological Notes. Amer. Jour. Sci., vol. xxix, 1885, p. 114. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band I, p. 484. Stuttgart.)

Abstract.

KAYSER. (Review.) C. D. Walcott: Note on Some Paleozoic Pteropods. Amer. Jour. Sci., vol. xxx, 1885, p. 17. (Neu. Jahrb. Min., Geol., u. Pal., 1886, Band II, p. 129. Stuttgart.)

Abstract.

KAYSER. (Review.) G. F. Matthew: Notice of a new genus of Pteropods from the Saint John group. Amer. Jour. Sci., vol. xxx, 1885, p. 293. (Neu. Jahrb. Min., Geol., und Pal., 1886, Band II, p. 129. Stuttgart.)

Abstract.

KAYSER. (Review.) E. Ringueberg: New Fossils from the Niagara Period of western New York. Mit 2 Tafeln. Proc. Acad. Nat. Sci., Philadelphia, 1884, p. 144. (Neu. Jahrb. Min., Geol., u. Pal., 1886, Band II, p. 132. Stuttgart.)

Abstract.

KÖENEN, VON. (Review.) Charles A. White: On marine, eocene, fresh-water miocene, and other fossil Mollusca of Western North America. Bull. U. S. Geol. Survey, No. 18, Washington, 1885. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band I, pp. 353, 354. Stuttgart.)

Abstract.

KOKEN, E. (Review.) Leidy: Fossil bones from Louisiana. Proceedings of the Academy of Natural Sciences of Philadelphia, 1884, p. 22. Vertebrate fossils from Florida. *Ibid.*, p. 118. Rhinoceros and Hip-potherium from Florida. *Ibid.*, 1885, p. 32. Remarks on Mylodon. *Ibid.*, p. 49. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band I, pp. 330, 331. Stuttgart.)

Abstract.

KOKEN, E. (Review.) F. Romer: Über Kreideversteinerungen aus Texas. Jahresb. d. schles. Ges. f. vaterl. Cultur, 1884, p. 227. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band II, p. 388. Stuttgart.)

Abstract.

KUNZ, GEORGE F. Agatized and Jasperized wood of Arizona. (Pop. Sci., Monthly, vol. XXVIII, pp. 362-367, January, 1886. New York.)

Description of the silicified forest of Arizona, known as "Chalcedony Park."

LAMPLUGH, G. W. On glacial shell-beds in British Columbia. (Quart. Jour. Geol. Soc., vol. XLII, pt. 3, pp. 276-286, August, 1886. London.)

Part I. Vancouver Island. Cites list of fossils given by G. M. Dawson in describing the glacial deposits of southeastern Vancouver, and gives a list of shells from glacial beds at Esquimault, Vancouver Island, the determination being by Mr. Clement Reid and Mr. Edgar Smith.

Part II. The Frazer Valley. Gives a list of shells from a railway-cutting on west bank of Harrison River, British Columbia, determined by Mr. Clement Reid.

LANGDON, D. W. Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 202-209, March, 1886. New Haven.)

Give a number of sections with lists of the fossils occurring in the various beds and describes two new species—*Verticordia eocensis* from Claiborne and Jackson, and *Bulla (Haminea) Aldrichi* from the same locality. The two species will be figured in the forthcoming report of the Geol. Survey of Alabama.

LANGDON, D. W. Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species. (Nature, vol. XXXIV, p. 46, 1886. London and New York.)

Notice of. See American Journal of Science, March.

LEIDY, JOSEPH. Mastodon and Llama from Florida. (Proc. Acad. Nat. Sci. Philad., vol. —, pp. 11, 12, March, 1886. Philadelphia.)

Proposes the names *Mastodon (Trilophodon) floridanus*, and three species of Llama which he names *Auchenia major*, *A. minor*, and *A. minimus*. Among the fossils from the same locality is an astragalus of *Megatherium*.

LEIDY, JOSEPH. Mastodon, Llama., etc., from Florida. (Proc. Philad. Acad. Nat. Sci., 1886, p. 11; Amer. Jour. Sci., 3d ser., vol. xxxi, p. 403, May, 1886. New Haven.)

Abstract of.

LEIDY, JOSEPH. An extinct Boar from Florida. (Proc. Acad. Nat. Sci. Philad., vol. —, pp. 37, 38, figs. 1, 2, March, 1886. Philadelphia.)

Describes provisionally the new genus *Eusyodon* and the species *Eusyodon maximus*.

LEIDY, JOSEPH. Caries in the Mastodon. (Proc. Acad. Nat. Sci. Philad., vol. —, p. 38, March, 1886. Philadelphia.)

Directs attention to a specimen, apparently exhibiting the result of caries, a condition never before observed by him in extinct animals, which he had attributed to a species under the name of *Mastodon Floridanus*.

LEIDY, JOSEPH. (See Koken, E.)

LENNOX, —. The Fossil Sharks of the Devonian. (Proc. Canadian Inst., 3d series., vol. III, pp. 120, 121, February, 1886. Toronto.)

Some descriptive notes on a specimen of *Machæracanthus sulcatus* from the corniferous limestone at St. Mary's, Ontario.

LESQUEREUX, LEO. (See Geyler.)

LYDEKKER, RICHARD. Catalogue of the Fossil Mammalia in the British Museum (Natural History), Cromwell Road, S. W. Part III. Containing the Order Ungulata, suborders Perissodactyla, Toxodontia, Condylarthra, and Amblypoda. pp. i-xvi and 1-186, figs. 1-30, 1886. London.

Contains many American species.

LYDEKKER, R. Catalogue of the Fossil Mammalia in the British Museum (Natural History), Cromwell Road, S. W. Part III. Containing the Order Ungulata, suborders Perissodactyla, Toxodontia, Condylarthra and Amblypoda. 8vo, pp. xvi and 186. London, 1886, printed by order of the Trustees. (Geol. Mag., new ser., Decade III, vol. III, pp. 425-427, September, 1886. London.)

Review of; mentions also some North American species.

LYDEKKER, R. Dr. Max Schlosser on the Ungulata. (Geol. Mag., new ser., Decade III, vol. III, pp. 326-328; July 1886. London.)

Review of; contains also much on American species.

I. "Beiträge zur Kenntniss der Stammesgeschichte der Hufthiere, etc.," Morphol. Jahrbuch, vol. XII, pp. 1-136, pls. i-vi. (1886.)

LYDEKKER, R. M. Dollo on the Evolution of the Teeth of Herbivorous Dinosauria. (Geol. Mag., new ser., Decade III, vol. III, pp. 274-276, diagrams A-C, June, 1886. London.)

Finally the American Cionodon stimulates the dentition of Ungulate Mammals in having numerous cheek-teeth in use at one and the same time.

(Original not seen.)

**McCHARLES, A.** The Extinct Cuttle-Fish in the Canadian Northwest. A paper read before the Canadian Institute, Toronto, March 14, 1885.

This is published by the author; the paper is only mentioned by title in the Proceedings of the Institute. Gives lists of the Lower Silurian fossils occurring at Stonewall, Stony Mountain, Lower Fort Garry, and Selkirk East, in the Winnipeg district.

**McCHARLES, A.** "The Extinct Cuttle-Fish in the Canadian Northwest." (Proc. Canad. Inst., 3d ser., vol. III, p. 270, June, 1886. Toronto.)

This paper has been separately published by the author.

**McGEE, W. J., and R. ELLSWORTH CALL.** On the Loess and associated deposits of Des Moines. Read before the Iowa Academy of Sciences, May 31, 1882. pp. 1-24, pl. on p. 19. December, 1882. New Haven, Conn.

This is a separate edition from the one in the Amer. Jour. Sci. Lists and tables of the fossils occurring are given, and eight species are illustrated on page 19.

**MARCOU, JOHN BELKNAP.** Department of the Interior, U. S. National Museum, serial number 40, Bulletin of the United States National Museum, No. 30. Published under the direction of the Smithsonian Institution.

Bibliographies of American naturalists.

III. Bibliography of publications relating to the collection of fossil invertebrates in the U. S. National Museum, including complete lists of the writings of Fielding B. Meek, Charles A. White, and Charles D. Walcott, pp. 1-333. 1885. Washington.

Contents. Introductory note. Part I. The published writings of Fielding Bradford Meek. Part II. The published writings of Charles Abiathar White. Part III. The published writings of Charles D. Walcott. IV. Publications based upon the paleontological collections of the United States Government, by Jacob Whitman Bailey, Timothy Abbot Conrad, James Dwight Dana, Christian Gottfried Ehrenberg, James Hall, Angelo Heilprin, Alpheus Hyatt, Jules Marcou, John Strong Newberry, David Dale Owen, James Schiel, Benjamin F. Shumard, Robert Parr Whitfield. Supplement, J. W. Bailey, T. N. Nicollet, Hiram A. Prout, Benjamin F. Shumard. Index of genera and species; general index.

**MARCOU, JOHN BELKNAP.** Biographies of American naturalists. III. Publications relating to fossil invertebrates. (Bull. 30, U. S. Nat. Mus., 334 pp. 8vo. Washington, 1885. Amer. Jour. Sci., 3d ser., vol. XXXII, p. 246, September, 1886. New Haven.)

Notice of contents of.

**MARCOU, JOHN BELKNAP.** Annotated catalogue of the published writings of Charles Abiathar White, 1860-1885. (Extracted from Bull. 30, U. S. National Museum, pp. 113-181. 1885. Washington.)

Four hundred copies of this extract from Bull. 30 were published by Dr. C. A. White.

**MARCOU, JOHN BELKNAP.** Annotated catalogues of the published writings of Dr. Charles Abiathar White. (Nature, vol. XXXIV, p. 246. 1886. London and New York.)

Notice of. See Bulletin of the U. S. National Museum, No. 30, pp. 113-181.



MARCOU, JOHN BELKNAP. Supplement to the list of Mesozoic and Cenozoic invertebrate types in the collections of the National Museum. (Proc. U. S. Nat. Mus., vol. ix, pp. 250-254, 1886. Washington.)

MARCOU, JOHN BELKNAP. Review of the Progress of North American Invertebrate Paleontology for 1885. (Amer. Nat., vol. xx, pp. 505-514, June 1886. Philadelphia.)

MARCOU, JOHN BELKNAP. Review of the Progress of North American Invertebrate Paleontology for 1885. American Naturalist, Extra, June 1886, p. 505. (Geol. Mag., Decade III, vol. III, p. 368. August, 1886, London.)

Notice of contents.

MARCOU, JOHN BELKNAP. Record of North American Invertebrate Paleontology for the year 1885. (From the Smithsonian Report for 1885, pp. 1-47, 1886. Washington.)

MARCOU, JOHN BELKNAP. North American Invertebrate Paleontology. P. 47 (Pop. Sci. Monthly, vol. XXIX, p. 885, October, 1886. New York.)

Notice of Mr. Marcou's record of paleontology in the Smithsonian Report for 1885.

MARCOU, JOHN BELKNAP. (See Dames.)

MARGERIE, EMM. DE. Esquisse de la Paleobotanique, par M. Lester F. Ward. (Polybiblium, tome XLVII, livraison de novembre, 1886. Paris.)

Review of Professor Ward's article in the 5th Ann. Report of the U. S. Geological Survey, 1883-'84.

MARSH, OTHNIEL CHARLES. Monographie des Dinocerata, mammifères gigantesques, Appartenant à un arbre disparu. (Ann. Sci. Geol., vol. XVII, pp. I-XI, 1885. Paris.)

A translation of the greater part of the introduction to Professor Marsh's monograph in the publication of the U. S. Geol. Survey, and reproduces a tabular statement of Marsh's classification of the Dinocerata.

MARSH, O. C. (See Branco.)

MATTHEW, GEORGE F. Illustrations of the Fauna of the St. John Group, continued. No. III.—Description of new genera and species, including a description of a new species of *Solenopleura*, by J. F. Whiteaves. (Proc. and Trans. Roy. Soc. Canada for the year 1885, vol. III, section iv, pp. 29-84, pls. v-vii, 1886. Montreal.)

The following are the new species described: *Archeocyathus* ? *paronoides*, *Protospongia* ? *minor*, *Eocoryne geminum*, *Dendrograptus* ? *primordialis*, *Protograptus alatus*, *Lingulella* ? *inflata*, *L. Dawsoni*, *L. linguloides*, *Acrotreta Baileyi*, *A.* ? *Gulielmi*, *Kutorgina latourensis*, *K.* ? *pterineoides*, *Orthis quacoensis*, *Hyolithes* (*Camerotheca*) *gracilis*, *Diplothea hyattiana*, *D. hyattiana* var. *A. caudata*, *Stenotheca hicksiana*, *S. concentrica*, *S. radiata*, *S. nasuta*, *S. triangularis*, *Lepiditta alata*, *L. curta*, *Lepidella anomala*, *Hipponicharion eos*, *Beyrichona papilio*, *B. tineæ*, *Primitia acadica*, *Agnostus regulus*, *A. partitus*,

## MATTHEW GEORGE F.—Continued.

*A. vir*, *A. vir* var. *A. concinnus*, *A. acadicus* var. *A. declivis*, *A. tessella*, *A. umbo*, *A. obtusilobus*, *A. acutilobus*, *Microdiscus punctatus* var. *precursor*, *Agraulos* ? *articephalus*, *Paradoxides arenaceus*.

In the above the following new genera and subgenera are described: In the Protozoa, *Eocoryne*; in the Hydrozoa, *Protograptus*; in the Pteropoda, *Camerotheca* (subgenus), and *Diplothea*; in the Gasteropoda, *Parmophorella* (subgenus), *Lepiditta* and *Lepidella*; in the Ostracoda, *Hipponicharion* and *Beyrichona*.

MATTHEW, GEORGE F. Abstract of a paper on the Cambrian Faunas of Cape Breton and Newfoundland. (Canadian Rec. Sci., vol. II, No. 4, pp. 255–258, 1886. Montreal.)

Abstract of a paper in the Trans. Roy. Soc. of Canada.

MATTHEW, GEORGE F. Synopsis of the Fauna in division 1, of the St. John Group, with Preliminary Notes on the Higher Faunas of the same Group. (Bull. Nat. Hist. Soc. New Brunswick, No. v, pp. 25–31, 1886. St. John, New Brunswick.)

MATTHEW, GEORGE F. The Structural Features of “*Discina Acadica*” (Hartt), of the St. John Group. (Can. Rec. Sci., vol. II, No. 1, pp. 9–11, figure on p. 11, 1886. Montreal.)

Gives some descriptive notes and a figure of a young specimen of *Stenotheca acadica*.

MATTHEW, GEORGE F. Discovery of a Pteraspidian fish in the Silurian rocks of New Brunswick. (Canad. Rec. Sci., vol. II, No. 4, pp. 251, 252, fig. p. 252, 1886. Montreal.)

Describes the fossil fish found on the southern slope of the Nerepis Hills, in King’s County, New Brunswick, from beds equivalent to the Lower Helderberg horizon of New York or the Ludlow of England, and proposes for it the name *Pteraspis* ? *Acadica*.

MATTHEW, GEORGE F. Pteropod of the St. John Group. (From a letter by Mr. G. F. Matthew, dated St. John, New Brunswick, December 8.) (Amer. Jour. Sci., 3d ser., vol. XXXI, p. 72, January, 1886. New Haven.)

States that there is no relation between *Diplothea* and *Phragmotheca* of Barrois. The lateral partition and diaphragms of *Diplothea* are features which distinguish it from other Hyolithoid shells.

MATTHEW, GEORGE F. Note on the occurrence of *Olenellus* ? *Kjerulfi* in America. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 472, 473, June, 1886. New Haven.)

Notes the occurrence of the fossil named in New Brunswick in the basin of the Kennebecasis River, where it is associated with a number of species found in the St. John basin in the bands *c* and *d* of Division I. The species are similar and in some cases identical with those of the Menavian Groups of Wales.

In Newfoundland *O. (?) Kjerulfi* occurs in association with *Agraulos strenuus*, *Hyolithes Micmac*, etc.

Mr. Matthews considers it doubtful whether it belongs to *Olenellus*, and says that among *Paradoxide* it is more closely allied to *P. Acadicus* than any other.

MATTHEW, GEORGE F. Additional note on the Pteraspidian fish found in New Brunswick. (Canad. Rec. Sci., vol. v, No. 5, pp. 323-326, 1887. Montreal.)

Some additional descriptive notes. The extras were distributed in 1886.

MATTHEW, GEORGE F. (See Kayser.)

MEYER, OTTO, and T. H. ALDRICH. The Tertiary Fauna of Newton and Wautubbee, Miss. (Jour. Cin. Soc. Nat. Hist., vol. ix, pp. 40-50, pl. II, July, 1886. Cincinnati.)

These fossils are all of Eocene age.

Gives a list of the species found, and describes the following new species: *Sigaretus*, subg., *Sigatica*, nov. subg., *Dentalium incisissimum*, *Cadulus abruptus*, *Fissurella altior*, *Scalaria (Opalia) albitesta*, *S. Newtonensis*, *Eglisia retisculpta*, *Natica Newtonensis*, *Sigaretus (Sigatica) Boettgeri*, *S. inconstans*, *Cerithiopsis quadristriatus*, *Cassidaria planotecta*, *Columbella mississippiensis*, *Murex cancellaroides*, *Marginella constrictoides*, *Cylichna volutata*, *Plicatula planata*, *Pecten pulchricosta*, *Venericardia complexicosta*, *Neaera (Cardiomya) multior-nata* *Xylophaga* ? *mississippiensis*, *Scalpellum subquadratum*, *Belemnosis Americana*.

MEYER, OTTO. Contributions to the Eocene Paleontology of Alabama and Mississippi. (Geol. Surv. Alabama, Bull. No. 1, pt. 2, pp. 63-85, pls. i-iii, 1886.)

Describes *Bovicornu*, n. gen., and the following new species: *Dentalium bitubatum*, *D. annulatum*, *Cadulus quadriturritus*, *C. turgidus*, *C. corpulentus*, *C. juvenis*, *Adeorbis subangulatus*, *A. laevis*, *Solarium hargeri*, *Scalaria gracilior*, *Eglisia pulchra*, *E. regularis*, *E. inaequistriata*, *Caecum solitarium*, *Crucibulum antiquum*, *Amaura tornatelloides*, *Rissoina mississippiensis*, *Aclis modesta*, *Turbonilla neglecta*, *T. mississippiensis*, *Odostomia bidendata*, *Chemnitzia acuta*, *Bittium koeneni*, *Cerithiopsis aldrichi*, *C. jacksonensis*, *Triforis similis*, *T. major*, *T. meridionalis*, *T. sp.*, *T. distinctus*, *T. bilineatus*, *Nassa mississippiensis*, *Cancellaria turritissima*, *Murex angulatus*, *M. simplex*, Aldrich, var. nov. *aspinosus*, *Murex simplex*, *Turricula cincta*, *Pleurotoma terebriformis*, *P. jacksonensis*, *P. infans*, *Mangelia meridionalis*, *Bulla bitruncata*, *Cylichna oviformis*, *C. jacksonensis*, *C. subradius*, *Actæon inflator*, *Styliola simplex*, *S. hastata*, *Bovicornu eocene*, *Arca inornata*, *Trigonocoelia ledoides*, *Leda mater*, *L. triangulata*, *Astarte protracta*, *A. triangulata*, *Micromeris sener*, *Lucina (Cyclas) subrigaultiana*, *L. choctavensis*, *L. Smithi*, *L. disculpta*, *Macra inequilateralis*, *Hindsella faba*, *Erycina Whitfieldi*, *Kelliella* ? *Boettgeri*, *Modiolaria Alabamensis*, *Corbula Pearlensis*, *Venus retisculpta*, *Echinocyamus Huxleyanus*.

MEYER, OTTO. The genealogy and the age of the species in the Southern Old Tertiary. Part III, reply to criticisms. (Nature, vol. xxxiv, p. 285, 1886. London and New York.)

Abstract of. See American Journal of Science, December, 1888.

MEYER, OTTO. Observations on the Tertiary and Grand Gulf strata of Mississippi. (Amer. Jour. Sci., 3d ser., vol. xxxii, pp. 20-25, July, 1886. New Haven.)

Mentions the occurrence of several fossils and concludes: (1) That he does not know any place where Grand Gulf strata can be seen in actual superposition over the Marine Tertiary. (2) There are two places where strata which can not be distinguished from unquestioned Grand Gulf can be seen actually overlain by Marine Tertiary. In one of these cases, moreover, there is actual evidence that these strata were dry land or nearly dry land before

**MEYER, OTTO—Continued.**

the Marine Tertiary was deposited upon them. (3) The Grand Gulf formation, at least for its main part, is not a marine formation; it contains fresh-water shells. (4) A thick and extended marine greensand formation with a numerous fauna is found in eastern Mississippi. It is parallel to the strata immediately below the Claiborne profile. Its fauna is Claibornian, but approaches the Jacksonian.

**MEYER, OTTO.** Observations on the Tertiary and Grand Gulf strata of Mississippi. (Amer. Nat., vol. xx, p. 969, November, 1886. Philadelphia.)

Abstract of.

**MEYER, OTTO.** Observations on the Tertiary and Grand Gulf strata of Mississippi. (Nature, vol. xxxiv, p. 330, 1886. London and New York.)

Notice of. See American Journal of Science, July.

**MEYER, OTTO.** Notes on the variation of certain Tertiary Fossils in overlying beds. (Amer. Nat., vol. xx, pp. 637, 638, July, 1886. Philadelphia.)

Describes variations in *Cytherea sobrina* Conrad, and *Ficus mississippiensis* Conrad, from the profile near Vicksburg.

**MIXER, FRED K., and HERBERT UPHAM WILLIAMS.** Fish remains from the Corniferous near Buffalo. (Bull. Buffalo Soc. Nat. Sci., vol. v, p. 84, 1886. Buffalo.)

Reports the discovery of a number of imperfectly preserved fish remains in strata of the Corniferous period, near Buffalo.

**MOORE, DAVID R.** Fossil Corals of Franklin County, Indiana. (Bull. Brookville Soc. Nat. Hist., No. 2, pp. 50, 51, 1886. Richmond, Ind.)

Gives lists of fossil-corals occurring in Upper and Lower Silurian, and in the Devonian drift of Franklin County, Indiana.

**MOORE, DAVID R.** Two hours among the Fossils of Franklin County, Indiana. (Bull. Brookville Soc. Nat. Hist., No. 1, pp. 44-45, 1885. Richmond, Indiana.)

Gives a list of Lower Silurian fossils found during a two hours' walk.

**MORRIS, CHARLES.** Methods of Defense in Organisms. (Proc. Acad. Nat. Sci., vol. —, pp. 25-29, March, 1886. Philadelphia.)

Throughout the whole history of the organic realm one principle holds good.

There has been a continued evolution of more rapid and varied powers of motion. To this every advance in organization has tended, while the hinderances to speed and flexibility have been successively discarded by the higher forms of life. In correspondence with this has been the development of mentality, since mentality, as outwardly displayed by the animals below man, is indicated by a greater intricacy of motions, in combination with ambush and concealment. For the attainment of the highest possible speed and strength little mentality was requisite, and brain development is manifested rather by intricacy than speed of motion—or rather by that well-ordered correlation of rest and diversified motion suited to the best good of the organism. Yet we must regard mentality as rather the effect than the cause of motor evolution. Probably the power of diversified motion appeared first while the exercise of any new power of this kind acted as an agent in the development of the brain. In other words, the evolution of the brain is a consequence of that of the body—not the reverse. P. 29.



NEWBERRY, J. S. The Flora of the Amboy Clays. (Bull. Torrey Botanical Club, vol. XIII, No. 3, pp. 33-37, March, 1886. New York.)

Abstract of a paper on the flora of the Amboy clays, at least one-third of the species seen to be identical with leaves found in the upper cretaceous clays of Greenland and Aachen (Aix la Chapelle), which not only indicates a chronological parallelism, but shows a remarkable and unexpected similarity in the vegetation of those widely-separated countries in the middle and last half of the Cretaceous age. Gives a brief synopsis of the flora of the Amboy clays.

NEWBERRY, J. S. Titanichthys and Dinichthys from the Devonian of Ohio. Trans. N. Y. Acad. Sci., vol. v, No. 2. (Amer. Jour. Sci., 3d ser., vol. XXXI, p. 405, May, 1886. New Haven.)

Abstract of.

NEWBERRY, J. S. Description of a species of *Bauhinia* from the Cretaceous Clays of New Jersey. (Bull. Torrey Botanical Club, vol. XIII, No. 5, pp. 77, 78, pl. lvi, May, 1886. New York.)

Describes the new species *Bauhinia cretacea*.

NEWBERRY, J. S. The Cretaceous Flora of North America. Illustrated by drawings and lantern views. Abstract. (Trans. N. Y. Acad. Sci., vol. v, 1885-'86, pp. 133-137, 1886. New York.)

Gives a brief history of what is known of the Cretaceous flora of North America, and calls attention to an important contribution to it, about to be published, from the Raritan and Amboy clays of New Jersey.

NEWBERRY, J. S. The Cretaceous Flora of North America. An abstract of a paper by Professor Newberry on the Cretaceous Flora of North America in the Transactions N. Y. Acad. Sci., No. 5, 1886. (Amer. Jour. Sci., 3d ser., vol. XXXII, p. 77, July, 1886. New Haven.)

NEWBERRY, J. S. (See Davis, W. M.; WEISS, ERNST.)

NICHOLSON, H. A. On some new or imperfectly known species of Stromatoporoids. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVII, pp. 225-270, 1886. London.)

No American species.

NICHOLSON, H. ALLEYNE. On some new or imperfectly known species of Stromatoporoids. Part II, pls. i, ii. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVIII, pp. 8-22, July, 1886. London.)

Describes *Stromatoporella granulata*, Nich., 1873; *Labechia Ohioensis*, Nich., 1885; *L. Canadensis*, Nich. and Murie, 1878.

NICHOLSON, H. ALLEYNE. A Monograph of the British Stromatoporoids. Part I, General Introduction, pp. i-iii and 1-30, figs. 1-17, pls. i-xi. (The Palaeontographical Society, instituted 1847, vol. for 1885. London, 1886.)

I. Historical introduction.

II. The general structure of the skeleton. (1) General form and mode of growth. (2) Chemical composition and mode of preservation. (3) The minute structure of the skeleton: a. The skeletal tissue; b. The radial

## NICHOLSON, H. ALLEYNE—Continued.

pillars and concentric laminae; *c.* Variations in the structure of these; *d.* The interlaminar spaces; *e.* The zoöidal tubes; *f.* The astrorrhizae; *g.* The astrorrhizal tabulae; *h.* The axial tubes; *i.* The epitheca; *j.* The surface; *k.* The reproductive organs.

## III. Systematic position and affinities of the stromatoporoids.

## IV. Sketch classification.

V. Families and genera of the stromatoporoids: (1) Actinostromidae. (2) Labechiidae. (3) Stromatoporidae. (4) Idiostromidae.

## VI. The nature of "Caunopora."

The following is a notice of the American genera and species:

*Actinostromidae*, Nich.

*Actinostroma* gen. nov., *Stromatopora*, Auctt.

*Clathrodictyon*, Nich. and Mur. Type *C. vesiculosum*, N. and M. Clinton and Niagara formation. In America there is also *C. cellulosum* N. and M. from the Corniferous limestone.

*Stylodictyon*, Nich. and Mur. Type *S. columnare*, Nich. From the Devonian of North America.

*Labechiidae*, Nich.

*Labechia*, Edwards and Haime, 1851. Type *L. conferta*, Lonsd. Two species at least of Lower Silurian age occur in North America, *L. Canadensis*, Nich. and Mur., Trenton limestone, and *L. Ohioensis*, n. s., Cincinnati group.

*Dictyostroma*, Nich. Type *D. undulatum*. Niagara limestone.

*Beatricea*, Billings. Types *B. undulata* and *B. nodulosa*. The balance of evidence seems to the author to be in favor of regarding *Beatricea* as an abnormal type of the *Stromatoporoids*.

*Stromatoporidae*, Nich.

*Stromatopora*, Goldf. (emend.). Type *S. concentrica*. Refers to this genus his own genus, *Pachystroma*, from the Niagara limestone.

*Stromatoporella*, nov. gen. Type *S. granulata*, Nich. From the Hamilton and Corniferous formations of western Canada. Refers to this genus probably *Stromatopora nulliporoides*, Nich., from the Devonian, and the allied or identical *Cænostroma incrustans*, Hall and Whitf., from the Devonian.

*Syringostroma*, Nich. Type *S. densum*. Nich. From the Devonian rocks of Ohio.

*Idiostromidae*, Nich.

*Idiostroma*, Winchell, founded for the reception of *I. caespitosum* and *I. gordiaceum*, from the Devonian rocks of North America.

Considering that the embedded tubes constitute the essential feature upon which *Caunopora*, Phill., and *Diapora*., Berg., were founded, the author thinks that the facts render it absolutely certain that these names can not be retained as names of genera.

Concludes that "the fossils ordinarily called '*Caunopora*' and '*Diapora*' are the results of the combined growth of some stromatoporoid with some coral, the former usually being a species of *Stromatopora* or *Stromatoporella*, and the latter generally belonging either to *Syringopora* or to *Aulopora*. We must also conclude, however, that there are other fossils in general aspect exceedingly similar to the ordinary '*Caunopora*,' in which the embedded tubes really do belong to the organism in which they are found, as we have seen to be the case in *Idiostroma oculatum*. In practice, therefore, each individual specimen must, with our present knowledge, be judged on its own merits, apart from all preconceived theories. Moreover, as the '*Caunopora*' and '*Diapora*' show many points of interest which are quite independent of any hypothesis as to their actual nature, I shall, where needful, describe and figure any noticeable features in connection with the '*Caunopora*-state' of certain *Stromatoporoids*, irrespective of all theoretical views as to the precise nature of this 'state.'"

NICHOLSON, H. ALLEYNE, and R. ETHERIDGE, jun. (*See Steinmann.*)

NICHOLSON, H. ALLEYNE, and A. H. FORD. (*See Steinmann.*)

NOETLING. E. D. Cope: On the structure of the skull in the Elasmobranch genus *Didymodus*. *Proceedings of the American Philosophical Society*, 1884; *Paleontolog. Bulletin* No. 38. (*Neu. Jahrb. Min., Geol. and Pal.*, 1886. Band. I, pp. 114, 115. Stuttgart.)

Abstract.

NOETLING. H. S. Williams: Notice of a new Limuloid Crustacean from the Devonian. *American Journal of Science and Arts*, 1885. (*Neu. Jahrb. Min., Geol., and Pal.*, 1886. Band. I, p. 344. Stuttgart.)

Abstract.

NOETLING. H. S. Williams: New Crinoids from the Rocks of the Chemung Period (Upper Devonian) of New York State. *Proc. Acad. Nat. Sci., Philad.*, 1882. (*Neu. Jahrb. Min., Geol., and Pal.*, 1886. Band. I, p. 360. Stuttgart.)

Abstract.

OWEN, RICHARD. On a New Perissodactyle Ungulata from Wyoming. (*Geol. Mag., new ser., Decade III, vol. III, p. 140, March, 1886. London.*)

In the *Geological Magazine* for February, 1886, it is stated, p. 50, that no Perissodactyle mammal was known to possess tubercular teeth. Professor Cope does not supply the characters to which his term "tubercular" is applicable. Sir Richard then says that he figured tubercular molars of *Phiolophus* from the Eocene in his *Paleontology* (2d ed., 1861), and that an earlier example is found in the genus *Hyracotherium*, described and figured in "*British Fossil Mammals and Birds*," 8vo., 1846, p. 422, cut 166; also from "*London Clay*." He states that his estimates of the claims of Elephants and Mastodons to rank as an "Order" rests upon the multilamellate structure, size, and succession of their "grinders," subordinate to which dental character may be cited a vertebral one, necessitating their special instrument, the proboscis.

OSBORNE, HENRY F. A new Mammal from the American Triassic. (*Science, vol. VIII, No. 201, p. 540, and fig., December, 1886. New York.*)

Describes *Microconodon tenuirostris* in the collection of the Philadelphia Academy of Natural Sciences, as on comparison he finds it to belong to quite a different genus from *Dromatherium sylvestre* Emmons, to which it had been referred.

OSBORNE, HENRY F. Observations upon the Upper Triassic Mammals, *Dromatherium* and *Microconodon*. (*Proc. Acad. Nat. Sci., vol. —, pp. 359–363, figs. 1–3, December, 1886. Philadelphia.*)

Describes the new genus and species *Microconodon tenuirostris*. This genus is founded upon the specimen in the collection of the Academy of Natural Sciences of Philadelphia, which was described by Emmons as *Dromatherium*. He also re-describes *Dromatherium sylvestre* Emmons. There are some portions of jaws described by Emmons from the Upper Triassic (Chatham coal-fields) of North Carolina.

PACKARD, A. S. Geological Extinction and some of its Apparent Causes. (Amer. Nat., vol. xx, pp. 29-40, January, 1886. Philadelphia.)

"That there is a limit to the age of species as well as to individuals almost goes without saying. As there is in each individual a youth, manhood, and old age, so species and orders rise, culminate, and decline." (This view was first propounded by Prof. Alpheus Hyatt.—Ed.) The causes, however complex, are, in the case of plants and animals, apparently physical; they are general and pervasive in their effects, and have been in operation since life began; there have been critical periods in paleontological as well as geological history, and periods of rapid and wide-spread extinction as well as continual, progressive dying out of isolated species.

PACKARD, A. S. Causes of the Extinction of Species. (Pop. Sci. Monthly, vol. xxix, p. 429, July, 1886. New York.)

Abstract of.

PACKARD, A. S. Discovery of the Thoracic Feet in a Carboniferous Phyllocaridan. (Read before the American Philosophical Society, February 5, 1886.) Proc. Amer. Phil. Soc., Philad., vol. xxiii, pp. 380-383, pl. p. 380.

Describes *Cryptozoe problematicus* Packard.

PACKARD, A. S. Discovery of Lamellate Thoracic Feet in the Phyllocarida. (Amer. Nat., vol. xx, pp. 155, 156, February, 1886. Philadelphia.)

Describes the thoracic limbs and regards the parts preserved as the homologues of the exopodites of Nebalia. The author named the specimen in MSS. *Cryptozoe problematicus*, as he was in doubt as to its affinities. A description of the new genus and species will appear hereafter, with figures.

PACKARD, A. S. (See Dames.)

PANTON, J. HAYES. Fragmentary Leaves from the Geological Records of the Great Northwest. A paper read before the Society on the evening of 24th January, 1884. (Manitoba Hist. and Sci. Soc., Winnipeg. Transactions, No. 4, season 1883-'84, pp. 1-9, 1884. Winnipeg.)

Mentions vertebræ, thigh bones, and a hip joint of "cretaceous dinosaurs" ?.

Mentions also the occurrence of various invertebrate Laramie and Cretaceous fossils.

PANTON, J. HAYES. Gleanings from Outcrops of Silurian Strata in the Red River Valley. A paper read before the Society on the evening of 27th November, 1884. (Manitoba Hist. and Sci. Soc., Winnipeg. Transactions, No. 15, season 1884-'85, pp. 1-13, 1884. Winnipeg.)

Gives lists of Silurian fossils occurring in the vicinity of Winnipeg.

PANTON, J. HAYES. Notes on the Geology of some Islands in Lake Winnipeg. A paper read before the Society on the evening of Thursday, 28th January, 1886. (Manitoba Hist. and Nat. Sci. Soc., Winnipeg. Transactions, No. 20, season 1886, pp. 1-10, 1886. Winnipeg.)

Mentions the occurrence of a number of genera of Silurian fossils.



PANTON, J. HAYES. Gleanings from the Geology of the Red River Valley. (Manitoba Hist. and Sci. Soc., Winnipeg. Transactions, No. 3, pp. 1-10, 1883. Winnipeg.)

Fossils of the Silurian age are talked about on pp. 3 and 4.

POHLMAN, JULIUS. Fossils from the Waterlime Group near Buffalo, New York. (Bull. Buffalo Soc. Nat. Sci., vol. v, pp. 23-32, pl. III, 1886. Buffalo.)

Describes *Pterygotus Buffaloensis* Pohlm.; *P. bilobus* Huxley & Salter; *Ceratiocaris acuminatus* Hall; and states that hereafter *Eusarcus scorpionis* should be known as *Eurypterus scorpionis* Grotte & Pitt.

POWELL, J. W. Fifth Annual Report of the United States Geological Survey, 1883-'84. 4to, pp. 1-469, plates 1-58, and 143 figures. Washington, Government Printing Office, 1885. (Geol. Mag., new ser., Decade III, vol. III, pp. 464-465, October, 1886. London.)

Notice of contents: "The Gigantic Mammals of the Order Dinocerata," by O. C. Marsh, and Sketch of Paleobotany, by Lester F. Ward.

PRATT, W. H. Proceedings of the Davenport Academy of Sciences, vol. IV, 1822-1884. Davenport, (?) Iowa, pp. 358, with six plates. Price, paper, \$4. (Pop. Sci. Monthly, vol. XXIX, pp. 706, 707, September, 1886. New York.)

Notice of contents of. The paleontologic memoirs in it were noticed in last year's review.

PROCEEDINGS of the Davenport Academy of Natural Sciences. Vol. IV, 1882-'84. Davenport, Iowa, 1886, pp. 348. (Amer. Jour. Sci., 3d ser., vol. XXXII, p. 82, July, 1886. New Haven.)

Notice of contents. It contains a paper on a new genus and species of Blastoid, by C. Wachsmuth; and on a new species of Blastoids, by W. H. Barris, with two excellent plates.

These papers were noticed in last year's review.

PUTNAM, F. W. Discovery of Mastodon Skull at Shrewsbury. (Proc. Boston Soc. Nat. Hist., vol. XXIII, p. 242, June, 1886. Boston.)

Mr. F. W. Putnam referred to the discovery of the mastodon skull at Shrewsbury a year ago, and described the continuation of the exploration of the peat deposit this autumn by the Worcester Society of Natural History, when a human skull was found. As stated to him by Dr. Raymenton, who took out the human skull, both skulls lay on the blue clay bottom of an ancient pond and were covered with from 6 to 8 feet of peat formation.

RAUFF, H. On the Genus *Hindia*, Dunc. (Ann. and Mag. Nat. Hist., 5th ser., vol. XVIII, pp. 169, 179, figs. 1-4, September, 1886. London.)

The author concludes that *Hindia fibrosa* is no doubtful form, not belonging at all to the sponges, as Professor Steinmann thought he was obliged to assume, but a well-characterized, true tetraceladine siliceous sponge.

REID, CLEMENT. (See Lamplugh, G. W.)

RINGUEBERG, EUGENE, N. S. New Genera and Species of Fossils from the Niagara Shales. (Bull. Buffalo Soc. Nat. Sci., vol. v, pp. 1-22, pls. I, II, 1886. Buffalo.)

*Squamaster*, n. gen., *S. echinatus*, *Protasta stellifer*, *Eugaster concinnus*, *Lecanocrinus solidus*, *L. nitidus*, *L. incisus*, *L. excaratus*, *L. puteolus*, *Platycrinus*

## RINGUEBERG, EUGENE, N. S.—Continued.

*corpariculus*, *Callocystites tripectinatus*, *Platyceras laciniosum*, *P. proclive*, *P. membranaceum*, *Pentamerella compressa*, *Spirifera asperata*, *Crania dentata*, *C. gracilis*, *C. pannosa*, *Avicula undosa*, *Conularia multipuncta*, *C. bifurca*, *C. transversa*, *Ceramopora orbiculata*, *Rhinopora curvata*, *Stomatopora recta*, *S. parva*, *Chaetetes expansus*, *Tuberculopora*, n. gen., *T. inflata*.

The species described are from Lockport, New York, from the lower part of the shale, with a few exceptions.

## RINGUEBERG, E. (See Kayser.)

ROMINGER, C. On the Minute Structure of *Stromatopora* and its Allies. (Proc. Acad. Nat. Sci., vol. —, pp. 39–56, March, 1886. Philadelphia.)

A criticism or review of the paper of Prof. Alleyne Nicholson and Dr. F. Murie on the structure of *Stromatopora*, published in 1879 in the Journal of the Linnæan Society of London.

ROMINGER, C. *Stromatopora*. (Amer. Jour. Sci., 3d ser., vol. XXXII, p. 78, July, 1886. New Haven.)

Dr. Rominger criticises the paper of Nicholson and Murie on the structure of *Stromatopora*, in the Proc. Nat. Sci. Philad. of 1886, pp. 39–56.

ROMINGER, C. On the Minute Structure of *Stromatopora* and its Allies. (Proc. Acad. Nat. Sci. Philad., 1886, pp. 29–56. Geol. Mag., new ser., Decade III, vol. III, p. 368, August, 1886. London.)

A criticism of Dr. Rominger's criticism of the joint essay of Professor Nicholson and Dr. Murie on the structure of *Stromatopora*, which appeared in the Journal of the Linnæan Society of London, in 1879.

## ROMER, F. (See Koken, E.)

SCHLOSSER, MAX. Beiträge zur Kenntniss der Stammesgeschichte der Hufthiere und Versuch einer Systematik der Paar- und Unpaarhufer. (Morphologisches Jahrb., Band XII, heft I, pp. 1–136, pls. I–VI, 1886. Leipzig.)

SCHLOSSER, MAX. Ueber das Verhältniss der Cope'schen Creodontas zu den übrigen Fleischfressern. (Morphologisches Jahrb., Band XII, heft II, pp. 287–294, 1886. Leipzig.)

SCHLOSSER, MAX. (See Cope, E. D.; Lydekker, R.)

SCHMIDT, OSCAR. The International Scientific Series. The Mammalia in their relation to Primeval Times. Pp. I–XII and 1–308, figs. 1–51, 1886. New York.

I. General Introduction.—(1) The Position of Mammals in the Animal Kingdom. (2) Phenomena of Convergence. (3) The Distinctive Characteristics of Mammals. (4) The Extension of Palæontological Science since Cuvier. (5) The Strata of the Tertiary Formation.

II. Special Comparison of the Living Mammals and their Ancestors.—(1) The Monotremata, Cloacal or Forked Animals. (2) The Marsupials. (3) The Edentata, or animals poor in Teeth. (4) The Ungulata, or Hoofed Animals. (5) The Elephants. (6) The Sirenia, or Sea Cows. (7) The Cetacea, or Whales. (8) The Carnivora, or Flesh Eaters. (9) The Seals. (10) The Insectivora, or Insect Eaters. The Rodents. The Bats. (11) The Prosimiæ, or Semi-Apes. Simiæ, or Apes. The Man of the Future.

SCHMIDT, OSCAR. Oscar Schmidt on the Origin of the Domestic Dog. The Mammalia in their relation to primeval times. New York, 1886. (Amer. Nat., vol. xx, pp. 370-372, April, 1886. Philadelphia.)  
Abstract of.

SCHMIDT'S Mammalia in their Relation to Primeval Times. (Amer. Nat., vol. xx, p. 450, May, 1886. Philadelphia.)  
Brief review of.

SCHRENK, JOSEPH. A. G. Nathorst on the Nomenclature of the Leaves of Fossil Dicotyledons. (Bull. Torrey Botan. Club, vol. XIII, No. 3, p. 38, March, 1886. New York.)

Abstract and translation of an article by A. G. Nathorst, in vol. xxv, numbers 1 and 2, of the Botanisches Centralblatt, on the difficulties which present themselves to the paleontologist in classifying and naming fossil dicotyledons on the characters of their leaves only, and proposes to designate those species of which the leaves only are known by the name of the genus with which they agree best, with the addition of the termination *phyllum*.

In order to meet another difficulty, the author proposes to adopt a ternary nomenclature. Suppose a leaf were found in Japan which resembles *Acer trilobatum* so much that it would not be advisable to make a new species of it, although the similarity is not perfect; this leaf ought to be called *Acer trilobatum Japonicum*.

SCOTT, [W. B.] *Cervus Americanus*, Harlan, from shell-marl beneath a bog in Warren County, New Jersey. The Fourth Annual Report (June, 1885) of the E. M. Museum of Geology and Archæology, of Princeton. (Amer. Jour. Sci., 3d ser., vol. xxxi, p. 72, January, 1886. New Haven.)

Abstract of.

SCOTT, W. B. On Some New Forms of the Dinocerata. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 303-307, figs. 1-4, April, 1886. New Haven.)

Proposes and describes the new genus *Elachoceras* from the Bridger beds of Henry's Fork, Wyoming, with *E. parvum* as the type species. Describes *Uintatherium alticeps*, n. sp.

SCOTT, W. B. On Some New Forms of the Dinocerata. (Nature, vol. xxxiv, p. 68, 1886. London and New York.)

Notice of. See American Journal of Science, April.

SCOTT, W. B. The Quaternary Moose of New Jersey. (Pop. Sci. Monthly, vol. xxviii, pp. 715, 716, March, 1886. New York.)

Abstract of Prof. W. B. Scott's article before the Academy of Natural Science, Philadelphia.

SCUDDER, S. H. The Earliest (Devonian) Winged Insects of America. 8 pp., with one plate. Cambridge, Mass. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 71, 72, January, 1886. New Haven.)

Abstract of.

SCUDDER, SAMUEL H. Note on the supposed Myriopodan Genus *Trichiulus*. (Mem. Boston Soc. Nat. Hist., vol. III, No. xiii, p. 438, 1886. Boston.)

States that on re-examination of the specimens there is no doubt at all that

## SCUDDER, SAMUEL H.—Continued.

they are ferns of the genus *Pecopteris* or one of its allies, preserved obscurely at the time of their partial unfolding; and that the name *Trichiulus* must disappear.

SCUDDER, SAMUEL H. The oldest known insect larva, *Mormolucoides articulatus*, from the Connecticut River rocks. (Mem. Boston Soc. Nat. Hist., vol. III, No. xiii, pp. 431–438, pl. xlv, fig. 1 on p. 431, 1886. Boston.)

Gives an elaborate and detailed description of the fossil named, and then discusses its relations and concludes that *Mormolucoides* is probably the larva of a Sialidan neuropteran.

It has special interest from the fact that it is the oldest known insect larva.

SCUDDER, SAMUEL H. A review of Mesozoic Cockroaches. (Mem. Boston Soc. Nat. Hist., vol. III, No. xiii, pp. 439–485, pls. xlv–xlviii, 1886. Boston.)

The author described the following new genera: *Ctenoblattina*, *Nannoblattina*, *Dipluroblattina*, *Diechoblattina* and *Aporoblattina*.

All of the new species described in this article are European.

SCUDDER SAMUEL H. The Cockroach of the Past. Reprinted from "The Structure and Life-History of the Cockroach (*Periplaneta Orientalis*)", by L. C. Miall and Alfred Denny, pp. 205–219, figs. 119–125, 1886. London.

Gives a table showing the geological distribution of fossil cockroaches.

SCUDDER, SAMUEL H. New Carboniferous Arachnid from Arkansas. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 310, 311, April, 1886. New Haven.)

Describes *Anthracomartus trilobitus*.

SCUDDER, SAMUEL H. Systematische Uebersicht der Fossilen Myriopoden, Arachnoideen and Insecten. Cambridge, Mass. (Sonderabzug aus Zittel, Handbuch der Palæontologie. I. Abtheilung. Palæozoologie, Bd. II pp. 721–831, 1885. Munchen and Leipzig.)

SCUDDER, SAMUEL H. Systematic review of our present knowledge of fossil insects, including Myriapods and Arachnids. (Bull. U. S. Geol. Survey, No. 31, pp. 1–128, 1886. Washington.)

While much fuller in the modern orders and families, these pages represent the English text furnished to Dr. Zittel for his *Handbuch der Palæontologie*, where the section forms the closing pages of the second part of the first volume (pp. 721–831), and is accompanied by more than two hundred illustrations.

The present bulletin is issued with the concurrence of Dr. Zittel and the publisher of the *Handbuch* for the convenience of English readers. A French version, under the auspices of M. Barrois, is also in course of simultaneous publication. The present is its original form and is the authoritative English edition.

Contents: Letter of Transmissal; Myriopoda; Bibliography; Characteristics and Phylogeny; Table showing Geological Distribution. (1) Order Protosyngnathe, Scudder. (2) Order Chilopoda, Latreille. (3) Order Archipolypoda, Scudder. (4) Order Diplopoda, Gervais, Arachnida—Bibliog-



## SCUDDER, SAMUEL H.—Continued.

raphy, Characteristics, and Geological history—Table showing Geological Distribution. (1) Order Acari, Leach. (2) Order Chelonethi, Thorell. (3) Order Anthracomarti, Karsh. (4) Order Pedipalpi, Latreille. (5) Order Scorpiones, Thorell. (6) Order Opiliones, Sundevall. (7) Order Aranae, Sundevall. Insecta; Bibliography; Characteristics and Development. A. Palæodictyoptera, Goldenberg. Bibliography. (1) Section Orthopteroidea, Scudder. (2) Section Neuropteroidea, Scudder. (3) Section Hemipteroidea, Scudder. (4) Section Coleopteroidea, Scudder. B. Heteromatabola, Packard. (1) Order Orthoptera, Olivier. Bibliography. (2) Order Neuroptera, Linne. Bibliography. (3) Order Hemiptera, Linne. Bibliography. (4) Order Coleoptera, Linne. Bibliography. C. Metabola, Packard. (5) Order Diptera, Linne. Bibliography. (6) Order Lepidoptera, Linne. Bibliography. (7) Order Hymenoptera, Linne. Bibliography, History, and Distribution of Fossil Insects. Tables showing the geological distribution of insects. Table of comparative distribution of extinct and existing orders. Comparative histories of Myriopoda, Arachnida, and Hexapoda. Table indicating the chronological range of preserved ancestral and extinct stocks. Index.

SCUDDER, SAMUEL H. Systematische Uebersicht der fossilen Myriapoden, Arachnoiden und Insekten, pp. 721–831 of Zittel's Handbuch der Palæontologie, I. Abtheilung, Palæozoologie, Bd. II, 1885. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 403–404, May, 1886. New Haven.)

Notice of.

SCUDDER, SAMUEL H. Scudder's Fossil Insects. (Amer. Nat., vol. XX, pp. 369, 370, April, 1886. Philadelphia.)

Brief review of Scudder's Contribution to Zittel.

SEELY, HENRY G. Department of the Interior. Report of the U. S. Geological Survey of the Territories: F. V. Hayden, U. S. Geologist, in charge, vol. III. The vertebrata of the Tertiary Formations of the West; Book 1, by Edward D. Cope. Washington, Government Printing Office, 1883. (Geol. Mag., new ser., Decade III, vol. III, pp. 410–419. September; *Id.*, 465–477; October; *Id.* 512–521, November, 1886. London.)

An illustrated review and abstract of the work.

SEELY, HENRY M. The Genus *Strephochetus*; Distribution and Species. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 31–34. July, 1886. New Haven.)

Specimens occur at points 60 miles apart, and wherever the middle Chazy occurs, either on the western or eastern side of Lake Champlain, there one may look for *S. ocellatus*. The author adds three new species, *S. Brainerdi*, *S. atratus*, and *S. Richmondensis*, Miller sp.

In issuing the extras the author also distributed two hektograph plates of illustrations of the genus.

SEELY, HENRY M. The genus *Strephochetus*; distribution and species. (Nature, vol. XXXIV, 1886. London and New York.)

Notice of. (*See American Journal of Science*, July.)

SHALER, N. S. Preliminary Report on the Geology of the Cobscook Bay District, Maine. Published by permission of the Director of

SHALER, N. S.—Continued.

the U. S. Geol. Survey. (Amer. Jour. Sci., vol. XXXII, pp. 35–60, figs. 1–13, July, 1886. New Haven.)

Fossiliferous Horizons of the Cobscook Series. The author gives several lists of species, and considers that he has horizons corresponding to the Lower Helderberg, Clinton, and Niagara groups of New York, and the dark Devonian Ohio shale of the Kentucky Geological Survey.

SHALER, N. S. Preliminary Report on the geology of the Cobscook Bay district, Maine. (Nature, vol. XXXIV, p. 330, 1886. London and New York.)

Notice of. See American Journal of Science, July.

SMITH, AUBREY H. The Railway Cutting at Gray's Ferry Road. (Proc. Acad. Nat. Sci., vol. —, pp. 253, 254, September, 1886. Philadelphia.)

Describes a bed of blue clay on the Schuylkill River, containing numerous genera and species of diatoms and several species of recent woods, and exhibited a specimen of wood, probably of a white cedar, *Cupressus thyoides*. This tree until very recently was common along the Schuylkill and Delaware, and isolated specimens may still exist there. The wood now shown is in no degree mineralized, and but slightly decomposed. This blue clay occurs at a depth of 25 feet through yellow clays and river gravels.

SMITH, EDGAR. (See Lamplugh, G. W.)

SPENCER, J. W. Niagara Fossils. (Trans. St. Louis Acad. Sci., vol. IV, No. 4, 1878–'86, pp. 555–624, pls. i–ix, 1886. St. Louis.)

A reprint of the article published in the Bull. Mus. Univ., State of Missouri, pp. 1–61, St. Louis, 1884.

SPRINGER, FRANK. (See Carpenter, P. Herbert.)

STEINMANN. Charles A. White: On the Mesozoic and Cenozoic Paleontology of California. Bull. U. S. Geol. Survey, No. 15, 1885, 33 S. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Bd. II, pp. 110–112, Stuttgart.)

Abstract.

STEINMANN. Charles A. White: On New Cretaceous Fossils from California. Bull. U. S. Geol. Survey, No. 22, vol. III, 25 S., 5 tafeln. Washington, 1885. (Neu. Jahrb. Min., Geol. u. Pal., Bd. II, pp. 112–113, 1886. Stuttgart.)

Abstract.

STEINMANN. H. A. Nicholson and A. H. Ford: On the Genus *Fistulipora*, McCoy, with descriptions of several species. Ann. & Mag. Nat. Hist., ser. 5, vol. XVI, pp. 496–517, t. xv–xviii, and 6 Holzschnitte, 1885. (Neu. Jahrb. Min., Geol. u. Pal., Bd. II, pp. 133, 134, 1886. Stuttgart.)

Abstract.

STEINMANN. H. A. Nicholson and R. Etheridge, jun.: On the Synonymy, Structure, and Geological Distribution of *Solenopora compacta* Billings sp. Geol. Mag. Dec. III., vol. II, No. 12, pp. I–XIII and H. MIS. 600—18

## STIENMAN—Continued,

529-535, December, 1885. (Neu. Jahrb. Min., Geol. u. Pal., Bd. II, pp. 134, 135, 1886. Stuttgart.)

Abstract.

STEINMANN. Angelo Heilprin: Notes on some new Foraminifera from the Nummulitic Formation of Florida. Proc. Acad. Nat. Sci. Philad. pp. 321, 322, 1884. (Neu. Jahrb. Min., Geol. u. Pal., Bd. II, p. 142, 1886. Stuttgart.)

Abstract.

STIRRUP, M. On some fossils from the Palæozoic Rocks of America, principally from the State of Indiana. (Manchester Geological Society, Trans., vol. XVIII, parts 10-19 (1884-'86), p. 331, 1885-'86. Manchester.)

Not seen.

TAUSCH, LEOPOLD. Ueber einige Conchylien aus dem Tanganika-See und deren fossile Verwandte, mit 2 tafeln, pp. 1-15. (Aus dem xc. Bande der Sitzb. der k. Akad. der Wissensch. 1; Abth. Juli. Heft. Jahrg., 1884.)

Reproduces the figures of *Pyrgulifera humerosa* Meek, given by Dr. White in his Review of the Non-Marine Fossil Mollusca of North America, and identifies with it specimens from Csingerthal bei Ajka in Bakony (Ungam), obere Kreide.

THORELL, T. On *Proscorpius osbornei*, Whitfield. (Amer. Nat., vol. xx, pp. 269-274, March, 1886. Philadelphia.)

The author can not find that *Proscorpius* differs essentially from the hitherto known scorpions in other respects than in the somewhat shorter *cephalothorax*, and perhaps in the form of the *mandibles*. Its systematical position appears to him to be in the close vicinity of *Palæophonus*, and especially of the Scotch scorpion referred to that genus by Mr. Peach. An additional reason to those given above for removing *Proscorpius* from the Carboniferous *Eoscorpionidae*, and for referring this genus to the *Apoxygones*, fam. *Palæophonoidæ*, may be found in its being, geologically speaking, almost contemporary with the *Palæophoni*, belonging, like these, to the Upper Silurian formation. As the *Palæophoni*, and all other more recent scorpions, are undoubted land animals and air-breathers, and as no traces of branchiæ have been shown to exist in *Proscorpius*, there is, he believes, no serious reason for considering that this scorpion is an aquatic animal, or that "we have here a link between the true aquatic forms, the *Eurypterus* and *Pterygotus*, and the true air-breathing scorpions of subsequent periods," as Mr. Whitfield supposes.

THORELL. (See Whitfield, R. P.)

TIFFANY, A. S. Geology of Scott County, Iowa, and Rock Island County, Illinois, and the adjacent territory. Showing the geographical and vertical range of the fossils of the Niagara, Corniferous, and Hamilton groups of rocks, and the Chemung group at Burlington, Iowa. With supplement, pp. 1-35, 1885. Davenport, Iowa.

Gives lists of (1) Niagara fossils of Le Claire and Port Byron; (2) Fossils of the Corniferous Group collected in Scott County, Iowa, and Rock Island

## TIFFANY, A. S.—Continued.

County, Illinois; (3) Fossils of the Hamilton Group collected in Scott County, Iowa, and Rock Island County, Illinois; (4) Fossils collected at Burlington, Iowa, from the yellow sandstone, believed to be the equivalent of the base of the New York Chemung; (5) Fossils collected in the Oolite band at Burlington, Iowa.

## TIFFANY, A. S. (See Barris, W. H.)

ULRICH, E. O. Descriptions of New Silurian and Devonian Fossils. (Contributions to American Palæontology, vol. II, pp. 3–35, pls. i–iii, 2 figs., on pp. 32, 33, May, 1886. Cincinnati.)

Author describes the following new genera and species: Middle Devonian species: *Fenestella bifurca*, *F. patellifera*, *F. pulchella*, *F. bigeneris*, *Semicoscinium obliquatum*, *S. infraporosa*, *Unitrypa retrorsa*, *Polypora transversa*, *Fistulipora normalis*, *Eridopora minima*, *Buscopora* n. gen., *B. dentata*, *Lichenotrypa* n. gen., *L. cavernosa*, *Discotrypa devonica*, *Schizobolus* n. gen., *Rhynchonella greeniana*, *Gypidia unguiformis*, *Platyceras quinquessinuatum*, *P. serratum*, *P. (?) arctiostoma*, *P. (Orthonychia) fluctuosum*, *Bucanophyllum* n. gen., *B. gracile*, *Strombodes separatus*, *Labechia montifera*, *Mællerina* n. gen., *M. greeni*.

ULRICH, E. O. Contributions to American Palæontology, vol. I, No. 1. Published by E. O. Ulrich, Cincinnati, 1886. 8vo. pp. 35, pls. i–iii. (Geol. Mag., new ser., Decade III, vol. III, pp. 374, 375, August, 1866. London.)

Notice and abstract of.

ULRICH, E. O. E. O. Ulrich's Contributions to American Palæontology, vol. I, Cincinnati, 1886. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 78, 79, July, 1886. New Haven.)

Notice of.

ULRICH, E. O. Report on the Lower Silurian Bryozoa, with Preliminary Descriptions of some of the New Species. (Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, pp. 57–103, 1886. St. Paul, Minn.)

Trenton group, new species: *Berenicea Minnesotensis*, *Ropalonaria pertenuis*, *Helopora divaricata*, *Phyllopora ? corticosa*, *Ptilodictya subrecta*, *Anthropora simplex*, *Stictopora mutabilis*, *S. mutabilis* var. *major*, *S. mutabilis* var. *minor*, *S. fidelis*, *S. paupera*, *Stictoporella ? cribrosa*, *S. angularis*, *S. frondifera*, *Pachydiictya foliata*, *P. occidentalis*, *P. fimbriata*, *P. conciliatrix*, *Crepipora impolita*, *Monticulipora grandis*, *Homotrypa Minnesotensis*, *H. exilis*, *H. subramosa*, *H. insignis*, *Homotrypella* n. gen., *H. instabilis*, *Prasopora simulatrix*, *P. conoidea*, *P. contigua*, *Diplotrypa infida*, *Aspidopora parasitica*, *Amplexopora Winchelli*, *Batostoma irrasa*, *Callopora undulata*, *C. incontracta*, *Trematopora primigenia*, *T. ornata*, *Bythopora Herricki*, *Monotrypella multitabulata*.

ULRICH, E. O. Remarks upon the names Cheirocrinus and Calceocrinus, with descriptions of three new generic terms and one new species. (Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minn., pp. 104–113, figs. 1, 2, and 3, on p. 106, 1886. St. Paul, Minnesota.)

The classification proposed is briefly defined as follows: *Cremaeriniide*, n. fam.; *Cremaerinus*, n. gen.; *Cremaerinus punctatus*, n. sp., type Trenton shales; *Deltaerinus*, n. gen., type *Cheirocrinus clarus*, Hall; *Halysioerinus*, n. gen., type *Cheirocrinus dactylus*, Hall; *Calceocrinus ?* Hall.



WACHSMUTH, CHARLES, and FRANK SPRINGER. Revision of the Palæocrinoidea. Part III. Discussion of the Classification and Relations of the Brachiote Crinoids, and Conclusion of the Generic Descriptions. Second section. (Proc. Acad. Nat. Sci. Philad., vol. —, pp. 65, 302, March and September, 1886. Philadelphia.)

Same, author's edition, pp. 65-334, contains, in addition to the article in the proceedings, an index of all generic and specific names used in connection with the Palæocrinoidea. The total number of genera recognized in this work is 156; species, 1,276. Of the genera, 61 were found exclusively in America, 48 exclusively in Europe, 46 on both continents, and 1 exclusively in Australia.

Part III, Section II, contains the Articulata and the Inadunata.

The Articulata include the group formerly defined by the authors under the family name of Ichthyocrinidæ, with the addition of *Crotalocrinus* and *Enallocrinus*, which possess in a remarkable degree some of the most characteristic features of the group.

The Articulata are divided into two families, the Ichthyocrinidæ and the Crotalocrinidæ, which are defined and the genera enumerated.

The Inadunata are divided into two branches, Larviformia and Fistulata W. and Sp. The Larviformia comprise the families Haplocrinidæ, Synbathocrinidæ, Cupressocrinidæ and Gasterocomidæ, which are defined.

Under the Haplocrinidæ are placed only two genera, *Haplocrinus*, Steiningcr, and *Allagecrinus*, Ether. and Carp.

Under the Synbathocrinidæ, W. and Sp., are placed the genera *Synbathocrinus*, *Phimocrinus*, *Stylocrinus*, *Stortingocrinus*, *Pisocrinus*, *Triacrinus*, and *Lageniocrinus*. They are uncertain whether to place *Rhopalocrinus*, W. and Sp. (Rev. 1, p. 57), among the Synbathocrinidæ, Cupressocrinidæ, Gasterocrinidæ, or be made a distinct group.

The Cupressocrinoidæ, Roemer, consist of only one genus, *Cupressocrinus*, Goldfuss.

The Gasterocomidæ embrace the following genera: *Gasterocomia*, *Nanocrinus*, and *Myrtilocrinus*.

The branch Fistulata contains the Cyathocrinidæ as previously defined by the authors, but which they now divide into Hybocrinidæ, Heterocrinidæ, Anomalocrinidæ, Cyathocrinidæ, and Poteriocrinidæ. To these they add the Belemnocrinidæ, Astylocrinidæ, and Encrinidæ.

Their present Cyathocrinidæ they subdivide into: Dendrocrinites, embracing the genera *Meroocrinus*, *Carabocrinus*, *Dendrocrinus*, *Homocrinus*, *Ampheristocrinus*, and *Parisocrinus*; Botryocrinites, embracing the genera *Alelelostocrinus*,\* n. gen. (and the new species *A. delicatus* and *A. robustus* are described under it), *Vasocrinus*, *Botryocrinus*, *Sicyocrinus*, *Streptocrinus*, and ? *Baryocrinus*. Cyathocrinites, embracing the genera without azygous plate, with branch-arms without pinules; *Cyathocrinus*, *Arachnocrinus*, *Gissocrinus*, *Sphærocrinus*, *Achradoocrinus*, *Codiocrinus*, and (?) *Leocythiocrinus*.

They subdivide the Poteriocrinidæ as follows: Poteriocrinites embracing the genera *Poteriocrinus*, *Scaphiocrinus*, *Scytalocrinus*, *Decadocrinus*, *Woodocrinus*, *Zacrinus* (and describe the new species *Z. nodosus*), *Hydreionocrinus*, *Calioocrinus*, *Eupachyerinus*, *Cromyocrinus*, and *Tribrachiocrinus*. Graphiocrinites embracing the genera *Graphiocrinus*, *Bursacrinus*, *Phialocrinus*, and *Cerioocrinus*. Erisocrinites embracing the genera *Erisocrinus* and *Stemmatocrinus*, and describe the new species *S. Trautscholdi*. They also define under this branch the Catillocrinidæ and Calceocrinidæ. Under the Hybocrinidæ, Zit-

## WACHSMUTH, CHARLES, and FRANK SPRINGER—Continued.

tel (Emend. W. & Sp.), are placed the genera *Bærocrinus*, *Hoplocrinus*, *Hybocrinus*, and *Hybocystites*.

Under the *Heterocrinidæ*, Zittel (Emend. W. & Sp.), are placed the genera *Heterocrinus* Hall (not Fraas), the new genus *Stenocrinus*\* with *Heretocrinus heterodactylus* as its type, the new genus *Ohioocrinus* with *Heterocrinus constrictus* as its type, and *Iocrinus* Hall. Under the *Anomalocrinidæ*, W. & Sp., is placed the genus *Anomalocrinus*. Under the *Belemnocrinidæ*, S. & Miller, are placed the genera *Belemnocrinus* and ? *Holocrinus*,† n. gen.

Under the *Encrinidæ*, Pictet, are placed the genera *Encrinus* and *Dadocrinus*. Under the *Astylocrinidæ*, Roemer, are placed the genera *Agassizocrinus* and (?) *Edriocrinus*. Under the *Catillocrinidæ*, W. & Sp., are placed the genera *Catillocrinus* and *Mycocrinus*. Under the *Calceocrinidæ*, Meek & W., is placed the genus *Calceocrinus* Hall (revised, W. & Sp.). In the appendix they define the family *Stephanocrinidæ*, N. & Spr., and place under it the genus *Stephanocrinus* Conrad.

They give some notes on the underbasals and top stem-joint of *Neocrinoidea* and *Paleocrinoidea*.

WACHSMUTH, CHARLES, and FRANK SPRINGER. Revision of the Palæocrinoidea. Part III. First Section. Philadelphia; William P. Kildare, Printer. Pp. 138, with 8 plates. (Pop. Sci. Monthly, vol. xxviii, pp. 710, March, 1886. New York.)

Notice of.

WACHSMUTH, CHARLES, and FRANK SPRINGER. Revision of the Palæocrinoidea. Part III. (Amer. Jour. Sci., 3d ser., vol. xxxi, p. 311, April, 1886. New Haven.)

Notice of.

WACHSMUTH, CHARLES, and FRANK SPRINGER. Revision of the Palæocrinoidea. Second section. Part III. From the Proc. Acad. Nat. Sci., March, 1886. (Amer. Jour. Sci., 3d ser., vol. xxxii, p. 410, November, 1886. New Haven.)

Notice of.

WACHSMUTH, CHARLES, and FRANK SPRINGER. Revision of the Palæocrinoidea. Part III. Philadelphia; Wm. P. Kildare, Pr., 1886, 8vo. (Science, vol. viii, No. 196, p. 421, November, 1886. New York.)

Review of and abstract from.

WACHSMUTH, CHARLES. (See Carpenter, P. Herbert.)

WADSWORTH, M. E. On a supposed Fossil from the Copper-Bearing Rocks of Lake Superior. (Proc. Boston Soc. Nat. Hist., vol. xxiii, pp. 208-211, May 7, 1884. Boston.)

The form which is probably from Copper Harbor, the author concludes to be inorganic; he also publishes an opinion from Prof. A. Hyatt to the same effect.

WALCOTT, CHARLES DOOLITTLE. Classification of the Cambrian System of North America. (Amer. Jour. Sci., 3d ser., vol. xxxii, pp. 138-157, figs. 1-9, August, 1886. New Haven.)

\* στενός, narrow; κρίνον, a lily.

† ὄλος, solid; κρίνον, a lily.

## WALCOTT, CHARLES DOOLITTLE—Continued.

A paper read before the National Academy of Science at Washington, D. C., April 23, 1886.

Many of the data in this paper are taken from the introduction of Bulletin 30, U. S. Geol. Survey, by the same author.

WALCOTT, CHARLES DOOLITTLE. Walcott on the Cambrian of North America. Amer. Jour. Sci., August, 1886. (Amer. Nat., vol. XX, pp. 800-802, September, 1886. Philadelphia.)

Abstract of.

WALCOTT, CHARLES DOOLITTLE. Classification of the Cambrian System of North America. (Nature, vol. XXXIV, p. 402, 1886. London and New York.)

Notice of. See American Journal of Science, August.

WALCOTT, CHARLES DOOLITTLE. Classification of the Cambrian System of North America. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 138-157, figs. 1-9, August, 1886. New Haven.)

Much of the data given in this paper is embraced in the introduction to the "Second Contribution to the Studies of the Cambrian Faunas of North America" (Bulletin 30, U. S. Geological Survey), although, owing to the delay in the publication of the latter, it appeared four months earlier. The most noticeable addition is the hypothetical map showing the land area during the deposition of the Middle Cambrian Strata, the description of its extent, and the disappearance of large portions of it just prior to the deposition of the formations carrying the Potsdam faunas. This broad generalization was developed by the study of the geographic and vertical distribution of the Cambrian faunas.

WALCOTT, CHARLES DOOLITTLE. Second contribution to the Cambrian Faunas of North America. (Bull. 30, U. S. Geol. Survey, pp. 225, pls. I-XXXIII, 1886. Washington.)

In this second contribution, Mr. Walcott has given a review of the stratigraphy of the Cambrian system in the United States, and a description of the faunas of the Middle or Georgia horizon of the Cambrian.

In the introduction the principal geologic sections of the Cambrian system are described and illustrated, and a general description of the Middle Cambrian horizon and its relations to the Lower and Upper Cambrian are given, and also the geographic distribution of the fauna on the North American continent.

In a résumé of the table of the Cambrian faunas of North America the following table occurs (bottom of page 61):

*Stratigraphic résumé.*

	Genera.	Species.
Upper Cambrian.....	52	213
Middle Cambrian.....	43	107
Lower Cambrian.....	32	76
	127	396
Re-appearances.....	35	3
Total fauna.....	92	393

## WALCOTT, CHARLES DOOLITTLE—Continued.

And also the table on page 62, as follows:

*Zoologic résumé.*

	Genera.	Species.
Algae .....	3	9
Spongiæ .....	6	13
Hydrozoa .....	4	5
Crinoidea .....	1	3
Annelida .....	2	5
Brachiopoda .....	15	67
Lamellibranchiata .....	1	1
Gasteropoda .....	14	29
Pteropoda .....	5	20
Crustacea .....	10	15
Pœcilopoda .....	31	226
	92	393

On page 63 a table of the classification of the North American Cambrian rocks shows that the Cambrian includes the Potsdam sandstone and the Lower Calciferous of the New York Survey as its upper member, and the *Paradoxides* beds of Braintree, Massachusetts, St. John, New Brunswick, and St. John's, Newfoundland, as the basal member, and the Georgia formation as the middle division.

The geologic sections given in the introduction show the Cambrian system "to have a total thickness of over 13,000 feet, and that its middle division has a known fauna of 43 genera, represented by 107 species; also that the Lower Cambrian or *Paradoxides* fauna has 32 genera and 76 species; that the Upper Cambrian or Potsdam fauna includes 52 genera and 212 species; that of the 393 species now known from the Cambrian rocks but very few pass up into the Calciferous horizon of the Lower Silurian (Ordovician), and that the faunas of the two systems are so distinct in their general facies, and also in detail, that they are quite as readily separated as the Silurian and Devonian, or the Devonian and the Carboniferous."

Ninety species, eighteen of which are new, are described and illustrated, and three new genera are proposed—*Leptomitrus* \* (Spongiæ), *Oryctocephalus*,† and *Protypus* (Trilobita). The almost unknown genera *Ethmophyllum*, Meek (Spongiæ), and *Olenoides*, Meek (Trilobita), are described; and the genus *Microdiscus*, Emmons (Trilobita) is redefined and based on another species, as its type species is considered to be an embryonic form of *Trinucleus concentricus*.

Paragraphs 119 and 120, page 57, state that: "Reviewing the Middle Cambrian fauna as a whole, we find that it combines the characters of both the Lower Cambrian and the Upper Cambrian faunas, and yet is distinct from either of them. There does not appear to be an equivalent fauna in the Cambrian system of Europe, either in Bohemia, the Scandinavian area, or in Wales. The nearest approach to it is on the island of Sardinia." (See close of remarks on the genus *Ethmophyllum*, p. 80.)

"The conditions that developed the Middle Cambrian fauna appear to have been largely peculiar to the American continent. During the deposition of the St. John series of the Lower Cambrian or *Paradoxides* strata, we learn from the European and eastern American section that the fauna was essentially of the same type over the entire basin (Atlantic), and from the evidence known to date that the fauna did not extend west of a line passing northeast through eastern Massachusetts to New Brunswick and Newfoundland."

The illustrations are wood-cuts, and are very good of their kind.

\* *Leptos* (fine), *mitos* (thread).

† *Ὠρυκτός* (furrowed), and *κεφαλή* (head).



## WALCOTT, CHARLES DOOLITTLE—Continued.

The following new species are described: *Archæocyathus Billingsi*, genus *Lep-  
tomitus*, n. gen., *L. Zitteli*, *Climacograptus* ?? *Emmonsii*, *Eocystites* ?? *longidac-  
tylus*, *Orthis* ? *Highlandensis*, *Orthisina* ? *transversa*, *O.* ? sp. undet., *Scenella* ?  
*varians*, *Hyalithes Billingsi*, *Hyalithes* sp. undet., *Leperditia* ? *Argenta*, *Microdiscus Parkeri*. Discussion of the relations of the genus *Olenellus* to other  
genera. Relations of the genera *Paradoxides*, *Mesonacis*, and *Olenellus*. *Ole-  
noides typicalis*, *O. levis*, *Ptychoparia housensis*, *P. Piochensis*, *Ptychoparia* sp. ?  
*Crepicephalus Liliana*, *C. Augusta*, genus *Oryctocephalus*, n. gen., *O. primus*,  
genus *Protypus*, n. gen., *Bathyriscus Howelli*.

WALCOTT, CHARLES DOOLITTLE.—(See Davis, W. M.; Kayser; White, Charles A.)

WALTHER, J. The Formation of Structureless Chalk by Seaweeds. (Science, vol. VII, No. 177, pp. 575, 576, June, 1886. New York.)

A description of the formation of chalk from *Lithothamnæ* in shallow waters in the Mediterranean, which gives a solution of various formations in geology, especially of the more recent chalk beds. Whether it will apply to the extensive structureless chalk beds of western Kansas at all is doubtful.

WARD, LESTER F. On the determination of fossil Dicotyledonous leaves. (Nature, vol. XXXIV, pp. 158, 1886. London and New York.)

Notice of. See American Journal of Science, May.

WARD, LESTER F. Note on a few imperfect leaf impressions from northern California. (Bull. U. S. Geol. Survey, No. 33, p. 16, 1886. Washington.)

The forms come from near Pence's Ranch, and Professor Ward remarks: "If it were certain that the specimen is either *Cinnamomum* or *Paliurus*, I should say that it could scarcely have come from a higher horizon than the Miocene and more likely from a lower. But the specimen may possibly represent a *Populus* unlike any modern form. At any rate I would not have been surprised at just such a collection from the Eocene or Laramie group."

WARD, LESTER F. Sketch of Palæobotany. Fifth Ann. Rep. U. S. Geol. Survey. (Science, vol. VII, No. 163, March, 1886. New York.)

Notice of.

WARD, LESTER F. Palæobotany. Fifth Ann. Report of the U. S. Geological Survey, 1883 to 1884. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 402, 403, May, 1886. New Haven.)

Brief abstract of contents of.

WARD, LESTER F. On the Determination of Fossil Dicotyledonous Leaves. (Amer. Jour. Sci., 3d ser., vol. XXXI, pp. 370-375, May, 1886. New Haven.)

A discussion of the new system of nomenclature in palæobotany recommended by Dr. A. G. Nathorst in the "Botanisches Centralblatt, Band XXVI, 1886.

WARD, LESTER F. (See Margerie, Emm. de.)

WEISS (ERNST). J. W. Dawson: The fossil plants of the Erian (Devonian) and Upper Silurian formations of Canada. Part II. Montreal, 1882. Geological Survey of Canada, S. 95-142, mit 4 tafeln. Hierzu sich gesellend einige Kleinere Abhandlungen desselben Verfassers:

Notes on New Erian (Devonian) plants, 1881. Dies. Jahrb. 1882. I, 129.

## WEISS (ERNEST)—Continued.

Note on a fern associated with *Platepnemera antiqua*, Scudder. Canadian Naturalist, vol. x, No. 2.

Notes on *Prototaxites* and *Pachytheca* in the Denbighshire grits of Corwen, N. Wales. Quart. Jour. Geol. Soc., May, 1882, S. 103.

Remarks on Mr. Carruther's views of *Prototaxites*. Monthly Microscopical Journal, August, 1873.

On Rhizocarps in the palæozoic period.

Comparative view of the successive palæozoic floras of Canada. Proceedings of the American Association for the Advancement of Science, vol. xxxi, August, 1882.

(Neu. Jahrb. Min., Geol. u. Pal., 1886, Band i, pp. 131-133, Stuttgart.)

Abstracts.

WEISS (ERNST). J. S. Newberry: Description of some peculiar screw-like fossils from Chemung rocks. Annals of the New York Academy of Sciences, vol. III, No. 7, p. 217, 1885. Taf. xviii, Figs. 1-3. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band i, p. 367, Stuttgart.)

Abstract.

WETHERED, E. On the Structure and Formation of certain English and American Coals. (Cotteswold Naturalists' Field Club. Proceedings for 1884-'85, p. 281. Gloucester.)

Not seen.

WHITE, CHARLES A. Charles Doolittle Walcott: Palæontology of the Eureka District. Monographs of the United States Geological Survey, vol. VIII, 4to., 298 pages, plates i-xxiv. Washington, 1884. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band i, pp. 115-117. Stuttgart.)

Abstract.

WHITE, CHARLES A. Robert P. Whitfield: Brachiopoda and Lamelli-branchiata of the Raritan Clays and Greensand Marls of New Jersey. Monographs of the U. S. Geological Survey, vol. ix, 4to., pp. i-xx and 1-264, plates i-xxxv. Washington, 1885. (Neu. Jahrb. Min., Geol. u. Pal., 1886, Band i, pp. 124-125. Stuttgart.)

Abstract.

WHITE, CHARLES A. Bulletins of the U. S. Geological Survey, Nos. 27, 28, and 29. Washington, Government Printing Office, pp. 80, 59, with plates and map, and pp. 24, with plates. (Pop. Sci. Monthly, vol. xxx, pp. 274-275, December, 1886. New York.)

No. 29 is a memoir on the fresh-water invertebrates of the North American Jurassic, by Charles A. White, M. D. (p. 275).

WHITE, CHARLES A. On the Fresh-Water Invertebrates of the North American Jurassic. (Bull. U. S. Geol. Survey, No. 29, pp. 1-24, pls. i-iv, 1886. Washington.)

The apparent identity of one or two of those species from the Black Hills with some which were found at the Cañon City locality, and of one or two species from the latter locality with some of those at Como, Wyoming, suggests an identity of horizon at the three localities; but even if the identity referred to is real the horizon of each locality may be more or less different, for it is believed that some of the species then existing may have passed from

## WHITE, CHARLES A.—Continued.

one horizon to another, even as certain fresh-water species are now known to have passed from the Laramie up into the Wasatch group. The character of the strata in which these fresh-water Jurassic fossils were found, both at the Colorado and Wyoming localities, in addition to the character of the fossils themselves, is such as to indicate for them a lacustrine and not an estuary or fluviatile origin. If the strata at both localities really contain an identical fauna, it may be regarded as probable that they were deposited in the same lake. The distance between the Colorado and the Wyoming localities indicates that the supposed lake was nearly 200 miles across; and if the Black Hills fossils also belonged to the same contemporaneous fauna, the assumed lake was much larger.

Indeed in view of the evidence we have (derived from both the vertebrate and invertebrate fossils) of the existing continental conditions and in view of the limited extent of recognized marine Jurassic deposits in North America and the doubtful age of some of the deposits which have been referred to that period, one can not say with confidence that any considerable part of the present North American continent was beneath the sea during any portion of the Jurassic period. In conclusion the author thinks it may be safely assumed that the great inland portion of our continent was not so permanently the seat of oceanic waters during Mesozoic time as has been supposed.

A synopsis and figures of all the known fresh-water fossils which have been discovered in the Jurassic rocks of North America is given, and the following new species are described: *Unio Felchii*, *U. toxonotus*, *U. macropisthus*, *U. iridoides*, *U. lapilloides*, *Limnæa ativuncula*, *L. consortis*, *L. ? accelerata*, *Vorticifex Stearnsii*.

WHITE, CHARLES A. On the Relation of the Laramie Molluscan Fauna to that of the succeeding Fresh-Water Eocene and other groups. (Bull. U. S. Geol. Survey, No. 34, pp. 1-35, pls. 1-v, 1886. Washington.)

Concludes that the strata in the western portion of our national domain form one uninterrupted series from the lowest of the marine Cretaceous formations to the top of the Bridger group, the uppermost of the fresh-water Eocene series, inclusive, both on account of the stratigraphical relations and the character and distribution of the fossil contents of the respective groups of strata.

The author gives a table showing the range of the species collected at the Wales locality on the western side of the San Pete Valley, with the addition of the *Helix* and *Pupa* obtained by Professor Cope from his Puerco group in New Mexico.

The new species described are the following: *Unio rectoides*, *Acella micronema*, *Physa bullata*, *Acrolorus actinophorus*, *Helix nacimientensis*, *H. adipis*, *Goniobasis filifera*, *Viviparus nanus*, and *Cypris sanpetensis*.

WHITE, CHARLES A. (See Koenen von; Steinmann).

WHITEAVES, J. F. (See Bailey, L. W.; G. J. Hinde).

WHITFIELD, ROBERT PARR. Fossil Scorpion from American Rocks, and other fossils. Bulletin No. 6 (vol. 1), American Museum of Natural History. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 228, 229, March, 1886. New Haven.)

Abstract of.

WHITFIELD, ROBERT PARR. Professor Thorell and the American Silurian Scorpion. (Science, vol. VII, No. 161, pp. 216, 217, March, 1886. New York.)

An answer to Professor Thorell's criticism in the American Naturalist, March, 1886, p. 269.

WHITFIELD, ROBERT PARR. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. (Monographs of the U. S. Geological Survey, vol. IX, pp. I-XX and 1-264, pls. I-XXXV. Washington, 1885.) Same. (Geological Survey of New Jersey; George H. Cook, State geologist, 1886. Trenton, N. J.)

The report, besides containing all the species hitherto described and published, contains the following new ones:

Section II. Lamellibranchiata Shells from the Plastic Clay: *Ambonicardia Cookii*, *Corbicula* ? *emacerata*, *Gnathodon* ? *tenuidens*. Section III. Lamellibranchiata from the Lower Marl Beds: *Pecten planicostatus*, *Amusium Conradi*, *Camptonectes parvus*, *Mytilus obliivius*, *Modiola Burlingtonensis*, *Pteria navicula*, *Gervilliopsis minima*, *Inoceramus pro-obliquus*, *Cibota obesa*, *Azinea alta*, *Nucula monmouthensis*, *Nuculana Gabbana*, *Trigonia Mortoni*, *T. cerulia*, *Gouldia Conradi*, *Lucina Smockana*, *Diceras dactyloides*, *Cardium* (*Protocardium*) *perelongatum*, *Pachycardium Burlingtonense*, *Fulvia tenuis*, *Fragum tenuistriatum*, *Leiopistha inflata*, *Sphærolia umbonata*, *Cyprimeria Heilprini*, *Dosinia Gabbi*, *D.* ? *erecta*, *Linearia contracta*, *Corimya tenuis*, *Veleda Tellinoides*, *V. transversa*, *Pholadomya Roemeri*, *Pholas* ? *lata*. Section IV. Lamellibranchiata from the Middle Beds: *Gryphæa Bryani* var. *precedens*, *Modiola* (*Lithodomus* ?) *inflata*, *Idonearca medians*, *I. compressirostra*. Section V. Lamellibranchiata from the lower layers of the Upper Marl Beds of New Jersey: *Ostrea glandiformis*, *Modiola Johnsoni*, *Cardita intermedia*, *Crassatella Conradi*, *C. rhombea*, *Criocardium nucleolus*, *Petricola Nova-Ægyptica*, *Valeda nasuta*, *Caryatis* ? *veta*, *Panopea elliptica*, *Periplomya truncata*. Section VI. Lamellibranchiata from the Eocene Marls of New Jersey: *Ostrea glaucomoides*, *O.* (*Alectrionia* ?) *linguafelis*, *Pecten Rigbyi*, *Nucula Circe*, *Nucularia secunda*, *Azinea Conradi*, *Astarte castanella*, *A. planimarginata*, *Cardita Brittoni*, *Crassatella obliquata*, *Caryatis ovalis*, *Velida equilatera*, *Corbula* (*Neura*) *nasutoides*, *Neura æqualvis*, *Parapholas Kneiskerni*, *Teredo emacerata*. Section VII. Unionidæ from the clays at Fish House, Camden County: *Unio præanodontoides*, *U. rectoides*.

The new genera which appear in the above lists are the following: *Ambonicardia*, *Meleagrinella*, and *Gervilliopsis*.

WHITFIELD, ROBERT PARR. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. Vol. I, 270 pages, 4to., with thirty-five lithographic plates of fossils and a colored geological map of part of the State. (Geological Survey of New Jersey, Trenton, 1886.) (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 324-325, October, 1886. New Haven.)

Review of. This book was first published as Monograph of the U. S. Geological Survey, vol. IX, Washington, 1885.

WHITFIELD, ROBERT PARR. Brachiopoda and Lamellibranchiata of the Raritan Clays and Greensand Marls of New Jersey. Washington, Government, 1885, 4to. (Science, vol. VIII, No. 196, p. 422, November, 1886. New York.)

Review of, and abstract from.



WHITFIELD, ROBERT PARR. Notice of Geological Investigations along the Eastern Shore of Lake Champlain, conducted by Prof. H. M. Seely and President Ezra Brainerd, of Middlebury College, with descriptions of the new Fossils discovered, by R. P. Whitfield. (Bull. Amer. Mus. Nat. Hist., vol. I, pp. 293-345, pls. xxiv-xxxiv, December, 1886. New York.)

Describes a group of fossils from the lake shore a few miles from Vergennes, Vermont, in a bed referred to the Birdseye limestone, which has yielded so far five Brachiopods, sixteen Gasteropods, twelve Cephalopods and one variety; two Trilobites and two bivalve Crustaceans; thirty-seven species and one variety, all in a recognizable condition, and are here illustrated; all but five of these are new to science. The following are their names: *Streptorhynchus*? *primordiale*, *Triplesia lateralis*, *Tryblidium orale*, *T. oratum*, *T. conicum*, *Clisospira lirata*, *Euomphalus circumliratus*, *Raphistoma compressum*, *Holopea Cassina*, *Lophospira Cassina*, *Ecculiomphalus volutatus*, *Calaurops lituiformis*, *Murchisonia*? *prava*, *Subulites obesus*, *Bellerophon Cassinensis*, *Orthoceras Brainerdi*, *O. cornu-oryx*, *Gomphoceras minimum*, *G. Cassinense*, *Piloceras explanator*, *Cyrtoceras Boycii*, *C. acinacellum*, *C. confertissimum*, *Nautilus Kelloggi*, *Nautilus*? *Champlainensis*, *Lituites Seelyi*, *L. Eatoni*, *L. internostriatus*, *Sao*? *Lamottensis*, *Bathyrurus*? *Seelyi*, *Lichas Champlainensis*, *Ribeiria compressa*, *R. ventricosa*.

The new genera described in the preceding list are as follows: *Under Gasteropoda* *Lophospira*, and *Calaurops*.\*

WHITFIELD, ROBERT PARR. Notice of Geological Investigations along the Eastern Shore of Lake Champlain, made by Prof. H. M. Seely and President Ezra Brainerd. (Amer. Nat., vol. xx, pp. 1041-1043, December, 1886. Philadelphia.)

Abstract of a paper announcing the discovery of quite an extensive new fauna in limestones, apparently of the age of the Birdseye limestone of the New York series, near the mouth of the Otter Creek, Lake Champlain, which is of much interest owing to the fact that only about fifteen species of fossils have hitherto been known from the formation. The new forms described in the paper from this one bed are fifteen in number, comprising one Brachiopod, six Gasteropods, and nine Cephalopods. One of the Gasteropods has given reasons for the establishment of a new genus *Lophospira*, with *Murchisonia*\* *bicineta* Hall, and *M. helicteres* Salter as the types. Subsequent collections made at the same locality give a total of forty recognized species in a condition suitable for description and illustration, of which the new ones are shortly to appear in a bulletin of the American Museum of Natural History.

WHITFIELD, ROBERT PARR. Notice of a new fossil body, probably a sponge related to Dictyophyton. (Bull. Amer. Mus. Nat. Hist., vol. I, pp. 346-348, December, 1886. New York.)

Describes a new genus and two new species from the slates at Kenwood near Albany, New York. The author names the new genus *Rhombodictyon*.† Under this he describes *Rhombodictyon reniforme*, and *R. discum*.

WHITFIELD, ROBERT PARR. (See Davis, W. M.; White, Charles A.)

\* Καλαῦρος, a shepherd's crook or staff.

† "In reference to the rhombic character of the species formed by the different sets of rods forming the network of their substance."

WILLIAMS, HENRY S. Devonian Lamellibranchiata and Species-making. (Amer. Jour. Sci., 3d ser., vol. XXXII, pp. 192-198, September, 1886. New Haven.)

A criticism of "Palæontology, vol. V, part I, Lamellibranchiata II, text and plates. Containing descriptions and figures of the Dimyaria of the Upper Helderberg, Hamilton, Portage, and Chemung groups, by James Hall, State Geologist, Albany, New York, 1885.

WILLIAMS, HENRY S. Devonian Lamellibranchiata and Species-making. (Nature, vol. XXXIV, p. 539, 1886. London and New York.)

Notice of. See American Journal of Science, September.

WILLIAMS, HENRY S. On the Classification of the Upper Devonian. Proc. A. A. A. S., vol. XXXIV, part I, pp. 222-234, 1886. Salem.)

Concludes: (1) That the Devonian black shales carry a fauna (B) which reappears with slight modification wherever the black shales appear, from the Genesee shales up through the Portage deposits to the Cleveland shale, and possibly higher. These deposits run out and disappear at the eastern extreme of the area. (2) The Portage rocks and their fauna (C) are comparatively local, belonging to the central part of the area, the fauna failing in the more western sections, and both fauna and lithologic characteristics are unrecognizable east of the Cayuga section. (3) It is evident from the study of the sections that the interval occupied in the Genesee section by the typical Portage fauna is represented in the Cayuga section by an entirely different set of species (the several stages of A), while still farther east in the Chenango and Unadilla section the same interval is filled by a preliminary stage of the Catskill (F. 1). (4) The Ithaca group of the State reports contains faunas (A., 3, 4) which he has defined as stages in the successive modifications of the Hamilton fauna. This set of faunas differs from the Chemung fauna in the absence of several of its common and abundant species, and by presenting unmistakable evidences of earlier stages in modification of species which are near enough alike to be classified under the same specific name. (5) The series of modified stages of the Hamilton fauna (A., 1-7) is confined to the sections east of the Canandaigua meridian. The lowest stage (A. 1) occurs at the extreme east, where the Tully limestone and the black Genesee shale are scarcely to be recognized. The third and fourth stages do not appear at the extreme east, but only in the Cayuga and Tiaghnioga sections, their place farther east being occupied by the first stage of the Catskill. The following stages appear in the more eastern and fail in the Cayuga section, while the final stage (A. 6 and A. 7) extends farther west, and appears after the Chemung species have appeared in the deposits of the region. (6) The Catskill deposits of Chenango and Otsego Counties are intrinsically not distinguishable from the upper stage of the Catskill, but appear at a lower position stratigraphically in the interval occupied by the "Ithaca group" of the Cayuga section and by the middle part of the Portage group of the Genesee section; but palæontologically they are immediately preceded by stages of the Hamilton fauna, and are followed by later stages of the same general fauna. (7) The Chemung fauna appears, in what I consider its earliest biological stage, in the central sections (D. and D. 1), but the predominant and most characteristic species of the Chemung appear stratigraphically earliest in the more western sections (D. 4 of Girard and Chataugua). This stage of the fauna appears in the upper part of the Chemung group of the more eastern sections, and when we reach the more eastern part of the area (the Chenango and Unadilla sections) this

## WILLIAMS, HENRY S.—Continued.

stage of the fauna is all that appears, and is there represented by a few specimens in the very upper strata just before the final incursion of the Catskill deposits.

WILLIAMS, HENRY S. Description of *Prestwichia eriensis*. Geol. Mag., September, 1885. (Amer. Nat., vol. xx, p. 157, February, 1886. Philadelphia.)

Notice of.

WILLIAMS, HENRY S. (See Dames; Davis, W. M.; Kayser; Noetting.)

WILLIAMS, HERBERT UPHAM. Notes on the Fossil Fishes of the Genesee and Portage Black Shales. (Bull. Buffalo Soc. Nat. Sci., vol. v, pp. 81–84, pl. on p. 81. 1886. Buffalo.)

Gives a short account of the fossil remains of fishes found in the Genesee and Portage black shales or their equivalents, with a few original observations, and describes two new species, *Palæoniscus reticulatus* and *P. antiquus*.

WILLIAMS, HERBERT UPHAM. (See Mixer, Fred. K.)

WILLIAMS, S. G. Westward Extension of Rocks in the Lower Helderberg period in New York. Abstract. (Proc. A. A. A. S., vol. xxxiv, part 1, pp. 235, 236. 1886. Salem.)

Mentions the occurrence of Lower Helderberg beds and fossils on Cayuga Lake, at the outlet of Skaneateles Lake and at Oriskany Falls.

WILLIAMS, S. G. The Westward Extension of Rocks of Lower Helderberg Age in New York. (Amer. Jour. Sci., 3d ser., vol. xxxi, pp. 139–145, February, 1886. New Haven.)

Mentions the occurrence of many fossils. The author thinks it would not be difficult to conceive why the Lower Helderberg should thin to the westward where the Salina appears in greatest volume, nor why it should there be represented by impure limestones, resembling the lowest portion of the eastern series, while more nearly synchronous with its higher portions. It would also be natural to expect, in this case, that the fauna of the western strata would consist of forms migrating from the east, and on this account, partaking largely of the life characters of the lower eastern deposits, since such migrations are likely to take place very slowly.

WILLIAMS, S. G. The Westward Extension of Rocks of Lower Helderberg Age in New York. Amer. Jour. Sci., February. (Amer. Nat., vol. xx, p. 372, April, 1886. Philadelphia.)

Brief abstract of.

WILLIAMS, S. G. (See Davis, W. M.)

WINCHELL, N. H. Notice of Lingula and Paradoxides from the red quartzites of Minnesota. Abstract. (Proc. A. A. A. S., vol. xxxiv, part 1, pp. 214, 1886. Salem.)

Merely calls attention to the discovery of the fossils mentioned.

WINCHELL, N. H. The Taconic Controversy in a nutshell. (Science, vol. vii, No. 153, p. 34, January, 1886. New York.)

A plea in favor of the use of the term "Taconic."

WINCHELL, N. H. Specimens registered in the general museum in 1885. (Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, for the year 1885, pp. 125-136, 1886. St. Paul.)

WINCHELL, N. H. New Species of Fossils. (Fourteenth Ann. Rep. Geol. and Nat. Hist. Surv. Minnesota, for the year 1885, pp. 313-318, pls. I, II, 1886. St. Paul.)

Describes: *Cryptozoon Minnesotense*, *Rhynchonella Ainsliei*, *Orthis remnicha*, and *O. Sandbergi*.

WOODWARD, ANTHONY. The bibliography of the Foraminifera, recent and fossil, including Eozoon and Receptaculites, 1565—Jan., 1886. (Fourteenth Ann. Rep. Geol. and Nat. Hist. Survey Minnesota, for the year 1885, pp. 167-311, 1886. St. Paul.)

WOOLMAN, LEWIS. Oriskany Sandstone in Lycoming County, Pennsylvania. (Proc. Acad. Nat. Sci. Philad., vol. —, pp. 296, 297, September, 1886. Philadelphia.)

Notes the finding of a bed containing Oriskany fossils, several of which are mentioned, which was previously supposed to be absent in that county.

WORTMAN, JACOB L. (See Cope, E. D.)

ZITTEL'S Handbuch der Palæontologie. Bd. I, Abth. II, Lief. 4, fossil Crustacea. (Amer. Nat., vol. xx, pp. 362, 363, April, 1888. Philadelphia.)

Brief review of.





## VULCANOLOGY AND SEISMOLOGY FOR 1886.

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In the preparation of this summary the author has made use of the following sources of information :

1. The current issues for the year of the following periodicals, viz :  
Science ; Nature ; American Journal of Science ; Comptes Rendus ; La Nature ; Le Tour du Monde ; Gaea ; Petermann's Geograph. Mittheilungen ; Mittheil. der K. K. Geogr. Gesellschaft, Wien ; Neues Jahrbuch für Mineralogie, etc. ; Mineral. u. Petrogr. Mittheil. (v. Tschermak) ; Jahrbuch der K. K. Geolog. Reichsanstalt, Wien.

Transactions of Seismological Society of Japan ; Proceedings of Royal Society, London, 1885 ; Report of Brit. Assoc. for Adv. Science, 1885.

2. Of the books, and separate reprints in the Bibliography, about one-half have come under the personal examination of the writer.

The subject matter will, as heretofore, be arranged under the following heads :

VULCANOLOGY.—Volcanic phenomena of 1886, volcanic phenomena of previous years, causes of volcanic action.

SEISMOLOGY.—Earthquakes of 1886, earthquake lists of 1885, catalogues of earthquakes of previous years, study of earthquakes.

SEISMOMETRY.—Instrumental records, instruments.

### VULCANOLOGY.

In describing the eruption of Etna, May 18 and 19, 1886, O. Silvestri notes that after the great eruption of August, 1874, by which the mountain was fractured from north-northeast to south-southwest, he predicted that another eruption would occur on the southern side of the mountain, where the fracture had not closed. This prediction was fulfilled in May, 1879. Again, in May, 1883, there was a third eruption from the same opening ; and it is still again from the same crevasse that the lava has issued in 1886. (Compt. Rend., cii, 1222.) The eruption of 1886 was somewhat severe, and at one time threatened the destruction of the village of Nicolosi. II. Silvestri calculates that the

output of lava from all the several openings amounted to from 40 to 60 cubic meters per second, and the rapidity of flow of the stream was from 40 to 60 meters per minute near the source. The stream extended in all 6.5 kilometers, stopping within 327 meters of Nicolosi, and the whole volume of lava emitted was estimated at 66,000,000 cubic meters. (Compt. Rend., CII, 1589.)

On the morning of June 10, 1886, a remarkable volcanic eruption began in the lake district of the North Island of New Zealand. By direction of the Government, acting with the utmost promptness, Dr. James Hector, director of the Geological Survey of New Zealand, at once began a scientific examination of the phenomena, starting with assistants for the scene of the outbreak on the afternoon of the same day on which the eruption commenced. His preliminary report, on which the writer has mainly relied for the following brief account, is given in *Nature*, XXIV, '89. The focus of the disturbance was ascertained to be in a line 7 to 10 miles long, extending in a northeast-southwest direction from the north end of the Tarawera Range to Okaro Lake. The outbreak began at 2.10 a. m. by an eruption from the top of Wahanga, the north peak, followed in a few minutes by a more violent one from Ruawahia, the middle peak, and a little later by a third one from the south end of the range. By the last explosion the mountain was split in two, and Percy Smith found the fissure to be 5 chains wide and the eastern part to have been blown away and scattered in débris over the country. (*Nature* XXXIV, 554.) The earthquake shocks at this time were not very severe. But about 4 a. m. a violent outburst of a different nature occurred, attended by loud reports and widely felt earth shocks. This was the outburst of an immense volume of steam, carrying pumice dust and rocks, which proceeded from the site of Rotomahana Lake, southwest of Tarawera, and formed a thick cloud in the higher atmosphere, where the vapor condensed to such an extent that the suspended solid matter fell in the form of mud, overwhelming the settlement of Wairoa to a depth of 12 inches. The site of this eruption is a great fissure which seems to commence as a narrow rift at the northern end from the great rent which has been formed in the south end of Tarawera Mountain. This rent appears as if a portion of the mountain, measuring 2,000 by 500 feet and 300 feet deep, had been blown out, leaving a ragged chasm, from which steam was issuing when observed. The great fissure cuts across Lake Rotomahana, where were formerly the famous Pink Terrace and White Terrace, but where there are now seven powerful geysers, at intervals throwing up water and mud to a height of 600 to 800 feet, the largest geyser rising from the position formerly occupied by the Pink Terrace. The rain of mud which overwhelmed the country is attributed to the condensation of the heavy vapor and dust cloud under the influence of a cold southwest wind. When visited steam was still rising from the site of Lake Rotomahana, forming a cloudy pillar 12,000 feet high. Dr. Hector

thinks that the eruption "was a purely hydrothermal phenomenon, but on a gigantic scale." An illustrated popular account of this eruption by C. F. Gordon Cumming may be found in "The Leisure Hour," October, 1886.

The changes that have occurred in the Hawaiian volcano of Kilauea during 1886 are of interest. On the evening of March 6, 1886, the lakes of liquid lava in this great pit crater were unusually active, but after midnight of that night the lava suddenly sank away, leaving the site of Halemaumau a great hole 500 feet deep. No overflow of lava occurred above the sea-level, although several rents were made outside of the crater. There may have been a submarine discharge (*Am. Jour. Sci.*, XXI, 397). Soon after this occurrence the crater was visited by J. S. Emerson, of the Hawaiian Government Survey, who remained there from March 24 to April 14. During his stay no molten lava was anywhere visible in the entire crater, although there were evidences of heat beneath the surface. He describes Halemaumau as a pit 600 feet in diameter and 275 feet deep. He made surveys of the crater and inferred that the lava which had disappeared had "found its way into the great fissures of 1868, and from the spongy nature of the district had readily found all the space needed to contain its entire volume without coming to the surface or entering the sea." (*Am. Jour. Sci.* XXXIII, 87.) About three months later L. L. Van Slyke remained at Kilauea from July 19 to 24. At that time the deep pit observed in April was replaced by a conical hill of loose rocks, some 150 feet high. Molten lava was also again visible in places, one being at the bottom of "a deep hole or well, of rather irregular outline, four-sided, perhaps 30 or 40 feet wide and from 60 to 75 feet long, and not less than 100 feet deep." (*Am. Jour. Sci.*, XXXIII, 95.) Again, at the beginning of October, it was visited by F. S. Dodge, who describes the pit of Halemaumau as now occupied by an irregular pit or lake, surrounded by a range of hills or ridge nearly circular in form and about 1,000 feet across. There appeared to be fire in the central pit, although he could not get near enough to actually see into it. (*Am. Jour. Sci.*, XXXIII, 98.)

A volcanic eruption was reported to have occurred in the island of Nina Föou, one of the Friendly Islands, beginning August 31, 1886, and continuing ten days, covering the greater part of the island with stones and ashes to a depth of 6 to 9 meters, killing the vegetation and destroying all the villages but two, with, however, but little loss of life. (Humboldt, 1887, p. 116.) It is noticed that the date of this eruption is the same as that of the Charleston earthquake (*Nature*, xxv, 127), but Professor Dana does not regard this as any reason for supposing a connection between the two. He notices the similarity in general direction of these islands with that of the volcanic line of central New Zealand (N. 30° E.), and thinks that this line, 1,500 miles long, "may be viewed as having been, at the beginning and since, the course of a series of fractures and a line of common genetic action," which would tend to



connect the eruption of Nina Föou with that in New Zealand in June, 1886, rather than with the Charleston earthquake. (*Am. Jour. Sci.*, xxxiii, 311.)

The new volcanic island which appeared in October, 1885, near the Island of Tonga, is pictured from photograph in Vol. XL, *Proc. Royal Soc.*, London. The island when visited in November, 1885, was about 2 miles long and 200 feet high.

In connection with the report of Dr. Johnston Lavis to the British Association (1886) on the volcanic phenomena of Vesuvius, the fourth sheet of the geological map of Monte Somma and Vesuvius was exhibited at the meeting. It distinguishes in detail the lava flows of different dates. The report states that unusual opportunities of studying the subterranean structure of the volcanic region about Naples are just now afforded by the construction of the sewer from Naples to the Gulf of Gaeta, by certain borings near the temple of Jupiter Serapis, and by the construction of the Cumana Railway from Naples to Baia and Fusaro. (*Nature*, xxxiv, 481.)

At the meeting of the London Geological Society February 19, 1886, Dr. Johnston Lavis received an award from the Barlow-Jameson Fund "in recognition of his past labors and in furtherance of future work in the vicinity of Naples." (*Nature*, xxxiii, 503.)

The volcanic phenomena of central Madagascar are described by R. Baron in *Nature* (xxxiii, 415). The volcanoes described, all now extinct and none so much as 1,000 feet high, lie in two districts, one fifty or sixty miles west and the other seventy or eighty miles southwest of Antananarivo, the capital. It is stated that scarcely a year passes without one or more slight earthquake shocks in central Madagascar. Extinct volcanoes and thermal springs are said to exist in other parts of the island, but little is known of them.

In a paper before the British Association (1886) on the geysers of New Zealand, E. W. Bucke gives observations on an extinct geyser, into the tube of which he was let down. He found that this tube, at 13 feet from the surface, opened into a chamber 15 feet long, 8 feet broad, and 9 feet high, from one end of which chamber another tube led downward to an unknown depth. His observations also indicate a connection between the activity of the geysers and the direction of the wind. (*Nature*, xxxiv, 512.)

In the second part of the ninth volume *Transactions of the Seismological Society of Japan*, Professor John Milne has published an account of the volcanoes of that country. The account is mainly descriptive and historical, the material being drawn from a number of Japanese works, a considerable portion of them being in manuscript. The information thus gathered from previous writers is supplemented by extended personal observations by the author himself in frequent journeys made for the purpose during his residence for a dozen years or more in Japan. Among these personal experiences may be mentioned his visit

to Oshima (p. 78), where he had an opportunity of looking down into the open crater of an active volcano, which was at the time belching forth masses of molten lava to a height far above the point where he stood. A map is given on which are marked one hundred and twenty-nine mountains of volcanic origin, twenty-three being in the Kurile Islands. Of this number, fifty-one are active, sixteen being in the Kuriles and eleven in Yezo. Of the whole, thirty-nine are symmetrically formed cones, showing a more or less close approximation to the theoretical outline deduced by Milne in the *Geological Magazine* and by Becker in the *American Journal of Science*, III, xxx, 283-293. From several considerations the author infers that the volcanoes of the Kuriles are of more recent formation than those of Japan.

Asama Yama is an active volcano about 75 miles northwest of Tokio, Japan, rising to 8,800 feet above sea-level. The depth of its crater being estimated by visitors all the way from 2,000 feet down to 500 feet. Professor Milne, with a party of assistants, attempted to measure this depth by a sounding line passed through a ring on a rope which was stretched across the crater. His measures, which were, however, not entirely successful, indicate the depth to be about 750 feet. (*Nature*, xxxv, 152.)

The volcano of Barren Island and the island of Narcondam in the Bay of Bengal were visited and surveyed by Capt. J. R. Hobday and F. R. Mallet, whose observations are published in the *Memoirs of the Geological Survey of India*. Barren Island is circular in shape, with a diameter of 2 miles. The main crater is elliptical, measuring  $1\frac{1}{2}$  by 1 mile, with walls varying in height from 1,158 feet on the southeast to nothing on the northwest. The inner cone, about half a mile in diameter at the base, rises 1,015 feet, terminating in a small elliptical crater 300 by 190 feet in measurement, from which steam and smoke issued. The outer slopes of the main crater, if prolonged, would meet above the apex of the inner cone, from which it is inferred that this outer cone was once complete, and that its upper part has been removed by an explosion similar to that of Krakatoa. (*Nature*, xxxiii, 489.)

On the authority of Junghuhn it has been believed that within historic times the volcanoes of Java have thrown out only solid matter and not lava. But observations on recent eruptions there, made by Herr Fennema, an engineer of Buitenzorg, show that in April, 1835, a stream of lava appeared on the southeastern side of Smeru which forced the residents of plantations below to flee, and caused some loss of life by avalanches of stones started by the stream. At the same time Lemongan also threw out a lava stream, but of a basaltic character, while that from Smeru was andesitic. (*Nature*, xxxiv, 224.)

Comparing with the eruption from Krakatoa that at the island Ferdinanda in 1831, A. Riccò remarks that at the latter place large quantities of vapor were projected into the air to a height comparable with that attributed to the emanations from Krakatoa, but, owing to the fact that

the eruption took place through the waters of the sea, the amount of solid matters which reached the upper atmosphere was inconsiderable. And as this eruption was followed by observations of the blue sun and red after glows at Palermo, he infers that the dust from Krakatoa could not have been a prominent factor in the production of the red sun-glows which attracted so much attention in 1883. (*Compt. Rend.*, cii, 1060.)

"Nature" also called attention to the relation between red sun-glows noted in Scandinavia in 1636 and 1783 and eruptions of Skapta Jökul in Iceland. (*Nature*, xxxiii, 137.)

In the president's address at the meeting in November, 1885, the Krakatão Committee of the Royal Society was reported to have their work in a good state of forwardness, the detailed work having been divided between five subcommittees.

The president's address in November, 1886, states that by working in connection with a similar committee from the Royal Meteorological Society the work is now nearly completed. Consideration of the sea disturbances, begun and carried on by Sir F. Evans, but interrupted by his death, has been completed by his successor in the office of hydrographer, Captain Wharton. The report on air disturbance by General Strachey and on geology by Professor Judd, as also that on sunsets and atmospheric phenomena, by Hon. Rollo Russell and Professor Archibald, are nearly ready in manuscript, and the completed publication may no doubt be expected at an early day. (*Nature*, xxxv, 114.)

The French translation of Verbeek's work on Krakatoa was completed in 1886, forming an octavo volume of 567 pages, printed at Batavia, accompanied by forty-three maps and plates, and an album of twenty-five plates, published by the National Institute of Geography in Bruxelles. It is characterized by Daubrée as "Un document classique dans les archives des volcans." (*Compt. Rend.*, cii, 1139.)

Edmond Cotteau has described Krakatoa and the Straits of Sunda as seen in the expedition of Breon and Corthals, in 1884, the article being illustrated with numerous views taken from the album accompanying Verbeek's volume. (*Le Tour du Monde*, li, 113.)

In September, 1885, J. M. Alexander, with J. S. Emerson, visited the crater of Mokuaweoweo, on Mauna Loa. He notes the curious fact that this volcano has had frequent eruptions from craters situated on the rim of the great central pit, so that lava streams have poured down inside the crater as well as outside. Having determined the position of over fifty small craters, he finds them apparently situated on a series of parallel fissures running in a direction S. 40° to 60° E., although a few are in lines running N. 50° E. He states that the "major axis of the great craters is generally at right angles" to the main trend of the group. This is certainly true of Kilauea and Mokuaweoweo, of which he says also that in both the highest walls are on the western side and the action is working toward the southwest, the most active craters being in each case in the southwest end of the caldera. (*Nature*, xxxiv, 232.)



Professor Dana (*Am. Jour. Sci.*, xxxii, 247) calls attention to the way in which the great erosion of the volcanic peaks in the island of Tahiti has displayed the inner structure of this mountain and so has made known what is probably the inner structure of many extinct volcanoes. The central mass of the mountain is made up not of bedded lavas, but of crystalline rock eroded into deep valleys separated by "knife edged" ridges and showing no horizontal lines but rather indications of vertical striation. He interprets this as being the solidified mass of lava which when liquid filled the interior of the volcano, and from which, since it solidified, the crater walls and overlying stratified beds have been washed away.

The first volume of Joseph Prestwich's *Geology* has been published during the year (Oxford, 1886). Chapter XII is devoted to volcanoes and in it he reiterates the views in regard to the agency of water in eruptions which he upheld in his paper before the Royal Society as noticed in our summary for 1885. Chapter XIII treats of earthquakes. In regard to the origin of earthquakes, while admitting other more local causes, he says "I am disposed to share the view expressed by Dana, that the tension and pressure by which the great oscillations and plications of the earth's crust have been produced have not yet wholly ceased and that this is generally the most probable cause of earthquakes." A map on Mercator's projections shows the geographical distribution of volcanoes and earthquakes.

#### SEISMOLOGY.

Much the most interesting occurrence of the year to Americans, and, indeed, the only earthquake which has attracted any general attention, was the destructive Charleston earthquake of August 31, 1886. In extent of area affected and in the magnitude of the destruction which ensued it surpassed anything that has occurred on the Atlantic coast since its occupation by Europeans.

The New Madrid earthquake of 1811, in the Mississippi Valley, was probably more violent, but, owing to the sparsely populated country, the material damage was much less. The first premonitions of the calamity were given by slight shocks felt at Charleston and Summerville on August 27 and 28, but the destructive shock occurred on the evening of August 31, within a few seconds of 9.51 p. m. By this shock nearly the entire city of Charleston was ruined, almost every house being more or less injured and very many rendered entirely uninhabitable, so that for many days thereafter a large part of the population lived in tents and other temporary shelters in the public parks. The shock was felt throughout the eastern United States, as far as Boston on the northeast, Toronto on the north, Wisconsin and Iowa to the northwest, Missouri, Arkansas, and Louisiana on the west. It was slightly perceptible in Cuba and the Bermuda Islands, to the south and east. Iso-seismal curves have been drawn by T. C. Mendenhall (*U. S. Weather*



Review, August, 1886) and by Everett Hayden (*Science*), from which, as well as from the coseismals, the origin or epicentrum appears to have been in the neighborhood of Charleston, probably somewhat north of that city. The greatest destruction was caused in the city of Charleston, although the direction of the shock appears to have been more nearly vertical at Summerville, about 25 miles northwest. At both of these places, but more particularly at Ten Mile Hill, between them, many "sand craters" were formed. These were openings in the ground, from which came out water and sand. They varied in size from little sand hillocks of an inch or two in diameter to large craters the sand from which covered a surface of some acres. The water at first spouted forth, but to no great height, and in most cases soon ceased to flow, although in at least one case it continued for more than three days. Fissures of considerable extent also occurred in other places. The main shock was followed by others that same night, none, however, of sufficient violence to have done harm except to buildings already weakened by the first. So in the following weeks shocks repeatedly occurred, at first daily and later at gradually increasing intervals; and they are still occasionally felt at the present writing, March 30, 1887.

Naturally this most unusual phenomenon at once attracted great attention, and Major Powell, director of the U. S. Geological Survey, immediately determined to take advantage of it for scientific study, for which it presented unusual opportunities. Competent persons were sent to make personal examination of the ground, and, by circular and otherwise, manuscript and printed reports were collected for future discussion. The results of this work are not yet published, but are expected to yield conclusions of the utmost interest and value. Of preliminary publications the following may be mentioned: A report by T. C. Mendenhall, accompanied by an isoseismal map, in the *United States Monthly Weather Review*; several communications to *Science* by Everett Hayden, of the Geological Survey, one accompanied by a map of isoseismals and coseismals prepared originally for the Washington Philosophical Society; an illustrated descriptive article in *Science* by W. J. McGee, of the Geological Survey; many newspaper accounts in the issues of the daily and weekly press during the month of September.

Dom Pedro, Emperor of Brazil, evinced his interest in scientific matters by himself sending to the French Academy an account of a moderate earthquake observed by him at his summer home in Petropolis, near Rio Janeiro, on May 9, 1886. It caused no important damage, but affected an area larger than that of the recent Andalusian earthquake, and is noteworthy as occurring in a region where earthquakes are rare. (*Compt. Rend.*, cii, 1351.)

The recording of the numerous minor shocks that are continually occurring still goes on both in Europe and in America, as is shown by the lists for 1885, which are now to be noted.

The Norwegian savant, Dr. Rausch, makes, in the Norwegian press, an appeal for more careful observation and report of earthquakes occurring in that region, with a view to preserving a record of their duration, extent, etc. (*Nature*, xxxiii, 424)

In his twenty-first annual report (*Min. u. petrog. Mitt.*, viii, 28) Dr. C. W. C. Fuchs has collected the statistics of vulcanology and seismology for 1885. The volcanic activity of the year is regarded as unimportant and is dismissed with brief references to the eruption of Vesuvius in May; of Cotopaxi in July, by which one hundred and two houses were destroyed; and of Smeru (Java) in April, by which a few lives were lost. His account of the earthquakes of the year includes two hundred and thirty items, which are distributed in time as follows: Winter, 30 (December, 20; January, 40; February, 30); spring, 61 (March, 27; April, 23; May, 11); summer, 40 (June, 18; July, 10; August, 12); autumn, 39 (September, 15; October, 14; November, 10). On twenty-six days earthquakes were reported at two or more places. Of these earthquakes the following receive more special mention: The series of shocks in southern Spain, which were a sequel to the great earthquakes of December, 1884, and continued to be felt at intervals far into 1885; an earthquake in Switzerland April 13, which affected an area of 20,000 square kilometers, and had an estimated intensity at the epicentrum of VIII, Rossi-Forel scale; in Steiermark May 1 and September 22, with limits well defined; in Cashmere May 24, by which 3,081 lives were lost and 70,000 houses injured; and in Algeria December 3 to 13, where villages were destroyed and numerous persons perished in the ruins. The list contains only seven American earthquakes, the deficiency being no doubt due to the same cause as noted in reference to the previous report. The one reported under date of January 6 probably should be January 2, Maryland, and January 3, New Hampshire. In an appendix he adds seventy-three items for 1883, nearly every one relating to Italian stations, and one hundred and twenty-one for 1884, of which many are Italian and forty-six are American, derived from Rockwood's lists for that year. In regard to these latter it must be noted that the geographical names and details have suffered seriously in the transfer to a foreign language, so that it is in some cases difficult to recognize for what they are intended.

Professor Rockwood's fifteenth Annual Notes on American Earthquakes (*Am. Jour. Sci.*, xxxii, 7) gives a summary for the year 1885. It is almost wholly occupied with North America, containing only five references to places south of the Isthmus of Panama. It gives 71 items classified in time, as follows: Winter, 24 (December, 8; January, 9; February, 7); spring, 22 (March, 8; April, 11; May, 3); summer, 14 (June, 3; July, 6; August, 5); autumn, 11 (September, 2; October, 7; November, 2). In geographical distribution they were: Canadian provinces, 8; New England, 5; Atlantic States, 9; Mississippi Valley, 3; Pacific coast of United States, 34; Alaska, 2; Mexico, 1;

Central America, 2; West Indies, 2; Ecuador, 1; Peru and Chili, 3; Argentine Republic, 1. As so many shocks occurred in California a small earthquake map of that State for the year is given, which shows that the Bay of San Francisco is in a particularly shaky region, that city having been within the area of five distinct earthquakes during the year. The author has again assigned an intensity to each earthquake, using the Rossi-Forel scale in combination with the one previously proposed by him (*Am. Jour. Sci.*, XXIX, 426), and which, having been adopted by the U. S. Geological Survey, is coming to be known as the American scale. Those earthquakes estimated as having an intensity of VI Rossi-Forel or over were—

(VI.)—March 30, Argentine Republic; March 30, April 11, July 23, California.

(VII.)—February 8, Mexico; July 31, California.

(IX.)—October 11, Nicaragua; December 18, Guatemala.

Forty-three dates are added for 1883 and 1884, all but one being in the latter year, and mainly taken from Detaille's lists in *L'Astronomie*.

M. C. Detaille contributes to *L'Astronomie* (p. 216) a list of earthquakes felt in 1885, being the third article of similar character from him. It gives 246 items in all, of which 35 are American. The largest number (49) occurred in January; the smallest (11) in October. For the other months the numbers are as follows: February, 18; March, 15; April, 19; May, 14; June, 29; July, 23; August, 13; September, 16; November, 6; December, 23. Of the American items only six are contained in Rockwood's lists, seventeen being from Venezuela and five from Valparaiso. After commenting on a few special earthquakes of 1885, he adds a list of thirteen earthquakes which occurred in Australia, Tasmania, and New Zealand from December 1, 1883, to December 1, 1884; notices some recent literature and gives the Rossi-Forel scale adopted by the Swiss Commission and now in quite general use.

The Croatian Earthquake Commission, by M. Rišpatić, published in 1885 (*Verh. K. K. Geol. Reichsanst.*) a report on the shocks of 1883. It enumerates forty-five shocks occurring on thirty-seven days. The greatest number of shocks occurred in Agram, where there were in all sixteen earthquake days. The origin of nearly all is referred to the mountains northeast of Agram (*Gæa*. XXII: 58).

Dr. C. W. C. Fuchs has collected the records of earthquakes from his various annual reports, arranged them according to countries and published the whole under the title "*Statistik der Erdbeben, 1865-85*" in the ninety-second volume of the *Sitzungsberichte* of the Vienna Academy; so that the statistics for any particular locality for the whole twenty years are now easily available to the student. It forms another chapter in the general earthquake catalogue in which Mallet and Perrey have preceded him. In order that the lists for different countries may be comparable one with another, Dr. Fuchs has included in his present lists only those shocks which were sensible without instruments;



that is, those which correspond to the numbers III to X of the Rossi Forel scale. The lists occupy about 400 octavo pages and are preceded by a brief separate notice of the more important shocks.

Prof. J. P. O'Reilly, of Dublin, has followed his catalogue of British earthquakes (1884) by a similar catalogue of "Earthquakes recorded as having occurred in Europe and adjacent countries." The British catalogue was referred to in the summary for 1884. The present list is based mainly on those of Mallet, Perrey, and Fuchs, and aims to give for each of the localities, arranged in alphabetical order, the number of recorded earthquake shakes, with their dates and condensed indications of the area affected. It forms a quarto volume of 220 pages. Owing to the difficulty of making any numerical estimate of intensity, especially with reference to shocks in past years, of which no sufficient details are now available, that element has been omitted in preparing this list, and it represents only the *number* of recorded earthquakes, the unit adopted being the "shock." The earthquake map of Europe, for which this list is intended to be the basis, has not yet appeared, but will be prepared in due time.

"Observations on the Volcanic Eruptions and Earthquakes in Iceland," by G. H. Boehmer, has been printed by the Smithsonian Institution from advance sheets of the Report for 1885. The first nineteen pages of this pamphlet are translated and condensed from a history by Th. Thoroddsen and describe the location of the active volcanoes. It is stated that "volcanic eruptions appear to be confined to two localities, one in the south of the island, running from southwest to northeast, and the other in the north, running from south to north." The volcanoes which have been active within historic times are classified geographically into eight groups, and under these headings they are described at some length. There follows a chronological and descriptive list of volcanic eruptions and earthquakes, beginning with Katla, about 900 A. D., and coming down to 1879. About twenty localities are named where eruptions have occurred. Of the large volcanoes Hecla has the first place with twenty-one eruptions. After it come Katla with twelve or thirteen, the Eldeyjar, near Reykjanes, with ten, and the Trölladýngja with six. The earthquakes are in evident connection with the volcanic activity. The remainder of the pamphlet, about 28 pages, is occupied with a valuable bibliography of the volcanoes, earthquakes, and geysers of Iceland, founded on a similar list by Thoroddsen but much extended by Mr. Boehmer. It names fifty-eight manuscripts, besides the numerous books and articles in journals.

In studying the slight earthquakes of January 5 and 17, 1886, in southern New Hampshire, W. M. Davis prepared (Appalachia, IV, 190), from the data in Rockwood's lists an outline map showing the areas in New England affected by earthquakes from 1872 to 1884, from which it appears that southern New Hampshire is the most frequently disturbed region. Professor Davis's detailed study of these shocks also confirms



what the present writer has long felt, that the newspaper notices on which so much of our records are based give a very insufficient idea of the true extent of the area affected, and gives added importance to the work undertaken by the Geological Survey looking to the collection of better records.

In the ninth volume of the Transactions of the Seismological Society of Japan, Dr. C. G. Knott has a paper on Earthquake Frequency. After a discussion of the probable length of any periodicity which might be due to the gravitational action of the sun or moon, with the result that the periods most likely to be discoverable are semi-annual and annual, he gives a method of combining the monthly numbers so as to eliminate any shorter periods; which method he then applies to several earthquake lists and finds clear indications both of a winter maximum and of a semi-annual periodicity. In regard to the latter, however, the author finds reason to doubt whether it is due to the gravitational cause which led to the search for it. He finds a possible or probable cause for the winter earthquake maximum (which his annual curves show to exist in both northern and southern regions), in the accumulations of snow over continental areas and in the annual change of barometric gradients.

Ch. V. Zenger, in searching for a possible relation between the cosmic streams of shooting stars and seismic phenomena, finds the following results (*Compt. Rend.*, CIII, 1288): (1) The days of the passage of the streams and of the solar perturbations coincide with the days of seismic movement during the years 1883, 1884, and 1885, and with volcanic eruptions. (2) When there is a considerable difference between the days of passage of the meteoric stream and the period of the solar perturbations, two groups of seismic movements are observed. (3) These movements are often accompanied by tempests, electric storms, and aurora borealis.

In a paper by Prof. J. S. Newberry, reprinted from the *School of Mines Quarterly*, he advocates the theory of a fluid or viscous interior and a comparatively thin and flexible earth-crust, and that earthquakes are the vibrations attending the folding and breaking of rocks which have been in a state of strain through its gradual contraction. He regards it as quite possible that the provoking cause in any particular case may lie in some comparatively trifling increase of atmospheric pressure or in the transfer of the products of erosion from the land to the bottom of the adjacent sea-basin.

M. Stanislas Meunier renews his theory of earthquakes (stated in 1883), by which he attributes the seismic activity to the effect of water contained in the rocks and suddenly brought under the influence of the internal heat of the earth, the means of its transfer to the superheated region being the sudden fall of masses of rock already saturated. He finds confirmatory evidence in the numerous shocks characterizing the recent earthquakes in Chios and in Spain. (*Compt. Rend.*, CII, 934.)

M. Ch. Lallemant presented to the French Academy a suggestion of

the origin of earthquakes in relation with the theory of the tetrahedral form of the earth proposed by Mr. Lowthian Green (*Vestiges of the Molten Globe*, 1875). According to this theory the four vertices of the terrestrial tetrahedral form are, respectively, in the Austral continent, the Himalayas in Asia, the Alps in Europe, and the Rocky Mountains in America, the several faces being occupied by the Indian, the Atlantic, the Pacific, and the Arctic Oceans, and the consequent areas of greatest deformation or lines of fracture should be the theaters of volcanic and seismic action, which indeed seems to be in accord with the physical facts (*Compt. Rend.*, cii, 715). This tetrahedral theory of the earth's form was also discussed before the Academy by M. H. Faye at its next meeting (*Compt. Rend.*, cii, 736). He showed that reasons for rejecting this theory were abundant, drawn from the unsymmetrical position assigned to the tetrahedral vertices and from the evident spherical form of the moon and planets. The details of his discussion belong rather to physical geography than seismology.

The promised monograph by Dr. Johnston Lavis on the earthquakes of Ischia has appeared during 1886, but as the writer has not yet seen it, nor any review of it, further notice of it must be reserved.

An important memoir by T. Taramelli and G. Mercalli on the Andalusian earthquakes of 1884 (*Atti R. Accad. d. Lincei*, 1886) has also come to the knowledge of the writer too late to receive more than mention.

In the fifth edition of the Admiralty Manual of Scientific Inquiry, the article on earthquakes, originally prepared by Robert Mallet, is to be revised by Prof. Thomas Gray, now of Glasgow and formerly in Japan. (*Nature*, xxxiii, 135.)

An account of "Earthquakes and earth movements," intended for the non-scientific reader, has been published in the International Scientific Series. It was prepared by Professor Milne, of Japan, who has had such a prominent part with Ewing, Gray, and others in the recent advances in seismology. It forms a book of 360 pages, divided into twenty chapters. It gives an excellent popular account of the subject, especially the part devoted to seismometry, in which are described a variety of instruments, from the simple columns of Mallet and the mercury cup of Cacciatore, to the modern seismographs of Ewing, Gray, and Milne. The character of the earthquake motion is discussed both theoretically and experimentally, with reference to Mallet's and Abbott's investigations, as well as to the experimental work done by the author and others in Japan. The effects on buildings are described and rules for building are inferred. In regard to the determination of the centre and epicentre several methods are given, dependent on the direction of the motion, on the direction of the cracks in buildings, and on time observations. For the latter case he treats mathematically (1) the method of straight lines, (2) the method of circles, (3) the method of hyperbolas, and (4) the method of co-ordinates; as also the methods of Haughton and of Seebach. The distribution of earthquakes in space

and time is illustrated, the former by a map based upon that of Mallet, and the latter by reference to the results of Mallet, Perrey, Schmidt, Fuchs, and others. In discussing the causes of earthquakes the usual theories of steam, vulcanism, chemical action, cosmic influence, are stated, the only conclusion being that the cause is endogenous to our earth, and that solar and lunar influences and barometric fluctuations have small effect. The last 40 pages are devoted to earth tremors, which escape notice by reason of their small amplitude; earth pulsations, which are overlooked on account of the slowness of their period; and earth oscillations, by which are meant such slow changes of level as are illustrated by the well-known temple of Jupiter Serapis. In regard to the earth tremors reference is made to the observations of d'Abbadie at Hendaye, of G. and H. Darwin at Cambridge, of Bertelli and Rossi in Italy, and of the author in Japan. The book is written in a popular style and, while dated 1886, appears to have been completed at least two years earlier, as it does not refer to the most recent work in this department, even that of Milne himself.

At the second annual conference of delegates of the "corresponding societies" enrolled in connection with the British Association, Professor Lebour stated that the North of England Mining and Mechanical Engineers had a committee actively engaged on the connection of earth tremors and mine explosions, and that they were desirous of organizing concerted observations on earth tremors by the corresponding societies. (*Nature*, XXXV, 80.)

In the re-modelling of the Imperial University of Tokio, with which the Imperial College of Engineering is now united, a chair of Seismology has been founded, and filled by the appointment of Mr. Seikei Sekiya, who has already become known by his previous work in that science. Japan is thus the first country to recognize the importance of this department of science by assigning to it a separate professor in its university. (*Nature*, XXXIV, 130.)

The French Academy appointed MM. Daubrée, Fouqué, Hébert, Gaudry, and des Cloizeaux as the Commission of Award for the Vailant prize, the subject for which was "to study the influence which the geology of a country, the action of water, or other physical causes might have upon earthquakes." (*Compt. Rend.*, CII, 541.) The prize was awarded to the members of the French Commission on the Andalusian Earthquake of December, 1884 (MM. Michel Levy, Bertrand, Barrous, Offret, Kilian and Bergeron), whose reports were referred to in the summary for 1885. They also awarded in the same connection an "encouragement" of 1,000 francs to M. de Montessus, who had passed four years (1881-1885) in San Salvador, and while there had made a careful study of seismism in its relations to other physical and cosmic phenomena. (*Compt. Rend.*, CIII, 1355, 1358.)

In 1885 the East Indian Section of the Dutch Royal Institution of Engineers published some prize questions, one of which related to the



theoretical methods and calculations employed in making deductions from earthquake observations. For this Prof. John Milne received the first prize of 150 guilders and a diploma. He also received honorable mention for an essay on the application of theoretical seismology to the art of house-building. (*Nature* xxxiv, 154.)

The Japanese Transactions of the Seismological Society of Japan have reached Vol. III, which contains papers on "Earth Tremors," by Milne; on the "Earthquake of October 15, 1884," by Sekiya; and on "Air Waves and Sea Waves," by Wada. The English Transactions of this active society have completed Vol. IX, the contents of which are referred to in their appropriate places in this summary.

#### SEISMOMETRY.

Early in the year Professor Milne read before the Seismological Society a paper on a seismic survey made in Tokio in 1884-'85. It is a fuller account of experiments briefly described in his "Fifth Report" to the British association, 1885. A number of similar seismographs were installed at different points on the grounds of the Imperial College of Engineering, one being at the bottom of a pit 10 feet deep, and another in a house supported on cast-iron balls. The instruments were connected and simultaneously put in operation by electricity. During the year of observation fifty earthquakes occurred, whose automatic records were studied. A map of the grounds is given and copies of some of the record diagrams. In general the results differed very sensibly at the various stations, the motion being usually greatest on the low grounds. The greatest amplitude marked at any station was 2.5 millimeters, while the same earthquake at another station gave only 0.05 millimeter. The greatest "maximum velocity" recorded is 19 millimeters per second. The greatest acceleration was 300 millimeters, or about 1 foot per second. In the house resting on shot the least motion was found when the shot used were small, about a quarter of an inch in diameter.

Experiments have been made with delicate instruments by MM. Fouqué and Levy on the velocity of propagation of vibrations in the soil, the vibrations being produced by dynamite and by the blow of a pile-driver. Some of their conclusions are of interest. (1) The vibrations caused by charges of dynamite or powder (up to 12 kilograms of dynamite) are, at the same distance, more feeble than those produced by a hammer of 100 tons falling from a height of 5 meters. (2) When the point of disturbance and the basin of mercury are both at the surface the vibrations are multiplied, showing several maxima and minima, and at a distance of 1,200 meters lasted 10 seconds. On the contrary, when the origin of the disturbance is below the surface, as in a mine, a single blow gives rise to a single shock of short duration, even when observed at a great distance; and the result is the same whether the mercury basin be in the mine or on the surface. (*Compt. Rend.*, CII, 1290.)



In a letter to *Nature*, under date February 28, 1886, Professor Sekiya gives a specimen of the earthquake records which are now issued from the University of Tokio. Regular observations are there made by the Meteorological Bureau by means of the horizontal pendulum and vertical motion seismographs of Milne, Gray, and Ewing, which produce continuous diagrams on a revolving glass plate or drum. The Meteorological Bureau has also carried out a set of observations for the determination of the area shaken in each earthquake, by means of reports gathered from over six hundred local offices throughout the Empire. The results are confirmatory of those reached by Milne in previous similar study. The total number of earthquakes in Japan in 1885 was four hundred and eighty-two, equivalent to 1.3 shakings per day. Of these two hundred and thirty-five were local, not affecting an area of more than 100 square miles. The maximum area of any one earthquake was 34,700 square miles. The intention to continue similar observations is announced. (*Nature*, xxxiii, 603.)

The Cambridge Scientific Instrument Company is now prepared to manufacture seismographic instruments after the designs of Prof. J. A. Ewing, of Dundee, formerly of Japan. The instruments are described by Ewing, with illustrations, in *Nature*, xxxiv, 342, and consist essentially of a pair of bracket seismographs for horizontal motions and a vertical motion instrument, all recording on a glass plate revolving by clock-work. The cost of this apparatus complete is £57 5s. The bracket seismographs with recording apparatus alone cost £40. The duplex pendulum seismograph, recording on a fixed plate and complete in itself, costs £14. These instruments are essentially similar to those described by Ewing in his memoir on Earthquake Measurement.

James White, of Glasgow, also advertises the Milne and Gray seismograph, improved from that figured in Milne's "Earthquakes," page 39, and made under Mr. Gray's personal supervision, for £55. It records both horizontal and vertical motions on a revolving drum, by means of two conical pendulum seismographs for the horizontal components and a compensated spring seismograph for vertical motions.

The U. S. Geological Survey has been experimenting on cheap forms of seismoscopes, which could be provided in considerable numbers and distributed to competent observers in the interest of its seismological work. Final results are not yet public, but good progress has been made toward an instrument which should meet the necessary conditions of reliability and cheapness.

Professor Ewing's instruments are in use at, or have been ordered by, the University, Tokio; the Meteorological Observatory, Tokio; the Geographical Bureau, Manila; the Ben Nevis Observatory; and the Lick Observatory, California. M. Cruls is also desirous of setting up seismographic instruments in the new building about to be erected for the Rio Observatory, Brazil. (*Nature*, xxxiv, 604.)

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## GEOGRAPHY AND EXPLORATION IN 1886.

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There appear to be few great regions left for the valiant explorers of modern times except those lying at the poles. A great deal still remains to be done in the way of working up the details that are needed to fill in the outlines of our globe's structure, which are now pretty well known. This is very clearly seen when we contrast the two species of activity at work in the study of Europe and Africa; the former might almost be said to be known so well as to preclude all further investigation, and this is true with regard to its general features, but we find more written about its details in every way, than of any other continent. In the case of Africa this sort of minute study has only begun, but the long lines traversed by so many intrepid men are rapidly producing a net-work which will give us a true idea of this enormous portion of our globe, concerning which it has been well said that it is a dark, mysterious, and sealed continent.

Europe has been properly retired from the list of the continents which are subjects for exploration, but the exploration of its resources and enterprises are in the first full flush of development; in other words, the history of man's modifying effect on nature has but fairly begun to be written.

Asia and Africa have received most attention during the past year, though there is no lack of expeditions of note in all the quarters of the globe.\*

*Asia.*—The greatest explorations which have been carried on in this continent during the past year have been those of General Prjevalski, who returned to Moscow in January, 1886, after his fourth journey into the interior. This is but one of a series of trips undertaken by him, commencing in 1871, and he was at that time the first explorer to penetrate these unknown regions, all other attempts having been repelled

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\* I have been aided very materially in the preparation of these notes by the excellent sketches of the progress of geography which have been published by Maunoir, Daveyrier & Kaltbrunner; not only in the verification of facts already known, but also for many records, which their greater facilities have enabled them to give.

by the fierce native tribes. A simple outline, giving the regions visited in these several journeys, may not be amiss in this place.

The first voyage extended from 1871-'73, during which time he visited and made known for the first time the sources of the Blue River, the Yang-tse-kiang. In his second trip he travelled through the Thian Shan region as far as the Tarim, and then he was forced to return through eastern Turkestan. This took place in 1876-'77. In 1878-'79, he explored the region about Lake Zaisan and reached Tsaidam in Thibet; then going forward, he was stopped within 160 miles of Sadji. He then turned his attention to the headwaters of the Hoang-ho. In his fourth journey, begun in 1883, he again crossed these central desert regions to the source of the Hoang-ho, spending the month of February, 1884, in the mountains of Thibet. In May he again passed through Tsaidam, where he left his stores in charge of the Cossacks. The river in this region has only a breadth of about 150 feet, which however soon increases rapidly. The Chinese have a great veneration for the Hoang-ho, which is justified by its importance to the region through which it flows. Wild animals, yaks, etc., are the only living things found near its source, but in its lower course, when the plains are reached, it becomes thickly settled. From these headwaters he turned farther southward to the source of the Yang-tse-kiang. Here he again encountered many difficulties, chief among which were the natives; they were generally poorly armed and easily repulsed, but he was exposed to their sudden attacks for several months.

Crossing from southern to western Tsaidam he found desert land once more, and he was glad to reach a small town called Gas, even though he was forced to take the most impracticable routes. Here he remained three months, and then passed on to western Thibet, where he discovered three new mountain ranges. On his return to Gas he passed through these mountains once more, going to Loto on his way. In this place he was received kindly by the inhabitants, who seem to be of Turkish origin. He received the same treatment from the natives of western China and eastern Turkestan.

This part of the country is described in the most favorable terms. It seems to have a warm and agreeable climate, to be very fertile, and winter is scarcely known. All the surrounding nations are represented here—Chinese, Mongolians, Arabians, and Hindoos. Going farther, another desert region was crossed, which was dotted here and there with oases; that of Tchertchen was found to contain the remains of an ancient and forgotten village; the Oasis of Potam is described as very fertile, and he is the first explorer who has followed and described the course of the River Potam. This river arises in a marsh in the midst of the desert, and has a length of about 120 miles; after following it he passed across the River Tarim and then went to the oasis of Akson. From this spot he crossed the Thian Shan mountains to Sekoul, where his journey ended.

Potanine and Skassi spent the greater part of the year in making ethnographic and topographic studies near Sinin and around Lake Koko nor, on the border lands between China proper and Thibet.

In southern Arabia we have had most interesting results from the voyage of Glaser. He crossed from Hodeida, on the Red Sea, to Sana, a voyage not so noted for its length as for the difficulties encountered. He has only been preceded by three Europeans (Niebuhr, 1763; Armand, 1843; and Halevy, 1870). This is one of the most famous portions of southern Arabia in ancient times.

Professor Euting, of Strasburg, has also published this year an account of the journey (made in 1883-'84) from Damascus to Nefond and from there to Mecca by a hitherto untraversed route.

A good map of central Syria has been published by Dr. Diener, which embodies the results of his studies around Damascus, Baalbec, southern Lebanon, and Palmyra.

The great cartographer H. Kiepert has been travelling through Asia Minor with the object of completing his map of that portion of the continent by the aid of original investigations and the unpublished documents to be found at Constantinople. As yet, however, nothing has been published.

Dr. Elisseev has started on a journey across Asior Minor to Armenia and Kourdistan by way of Alexandretta and Aleppo.

The party, composed of Potanine, Skassi, and Beresovski, which has explored a considerable part of southern Mongolia and northwestern China, continued their work in the spring, and started on their return across the desert of Gobi by a route lying between Sogok-Nor and the eastern ramifications of the Altai Mountains.

There has been another expedition in Thibet which deserves mention. The English explorer Carey has passed through western Thibet. From Leh, in Cashmir, he went to Khotan, then, following the course of the Tarim, he reached Lob Nor towards the end of April, and proposed to return by the north of China.

Another expedition, which was known as the Macaulay mission, has been ordered back because of the opposition of the Chinese Government. It was to have gone to Lhassa, crossing Sikkim and Japela Pass.

Upper Assam has been visited by Colquhoun, but no reports have been received from him concerning the region lying between Birmah and Assam. The border line of British India has been very carefully and energetically mapped by the English topographers, who were sent there for the purpose.

In the French possessions of Indo-China, the investigations of Reviellere and Fresigny have demonstrated that the rapids, heretofore considered insurmountable difficulties, can be passed by small steamers, as they went as high as Khong, on the Mekong river. The boundary commission have been at work in the North, near Laokai, where they have



nearly finished their work on the border between Yun-nan and Tong-king. They have been much interrupted by the piratical attacks of the natives.

Capus, Bonvalot, and Pepin have continued their travels in the trans-Caspian district and Turkestan. They always hoped to be able to cross the Afghan boundary, but have been unable to do so. After reaching the sacred city of Meshed, this season they decided to go at any risk, and started for Balkh. They were captured, safely returned to the border, and left on the other side in a very emphatic but respectful manner. They have explored the regions about Merv and Samarkand and have followed the course of the Amu-Daria.

The Russian Government sent out a party under Dr. Radde to examine into the resources of the new trans-Caspian territory. They were detained at Askabad by a tardy spring. They profited by the delay to explore the mountains on the Russo-Persian frontier. At Merv he was joined by Koutchine. From this point they went along the Murghab to the frontier of Afghanistan, and then followed the boundary to Saraklis and then to Askabad, studying the five parallel mountain chains on the border of the new Russian provinces.

Mr. and Mme. Dieulafoy are still continuing their researches in Persia, Chaldea, and Susiania, and although their work is mainly archaeological, it contains much of interest to the geographer. At this time the interest centers in the description of their return trip from Susa to Bassorah.

Persia has also been crossed by Captain Gore of the Afghanistan boundary commission. He was accompanied by a party of native topographers, and starting from the Oxus he traveled through Herat, Burjum, and then across the desert of Luth to Kerman; here the latest news was received from him, and his objective point was Bunder Abbas at the mouth of the Persian Gulf.

The Russian Government sent an expedition this year into eastern Pamir to study the botany of the region. It was the expedition of Grun-Grzymailo, and failed to reach the higher portions of the Pamir on account of bad weather.

The English government of India represented by Lord Dufferin sent Ney to Kashgar and Yarkand in 1885. The explorations of Ney in Central Asia have already made him famous. In this instance he profited by the occasion to cross that portion of the Pamir which has been considered inaccessible heretofore, and reached the headwaters of the Amu Daria. He then explored the regions of Roshan and Shighnan, which had only been visited by the pundits previously. After this he passed through Badakshan, and then reaching the English boundary commission in Afghanistan, went to Ladak, where he has resided for some time.

The Hindoo Koosh range was also crossed by Colonel Lockhart. Near the southern sources of the Amu Daria he passed through Badakshan,

after which he regained his starting point at Gilgit after having made topographical studies of some importance.

*Africa.*—The continent of Africa is becoming better known every year, but at the cost of many lives; in fact it is hard to tell whether the polar regions oppose more difficulties to overcome in exploration than these equatorial regions or not. Both parts of the globe have great natural obstacles to be overcome, but those found near the equator are intensified by the stubbornness, jealousy, and tricky dispositions of the natives. Thus each year a new list of victims to their barbarity has to be prepared, but this does not seem to prevent men risking their lives in the exploration of the dark continent.

Robecchi of Cairo has started across the Libyan desert from the Nile to Tripoli. The latest news from him was to the effect that he had reached the Oasis of Siwah safely.

Italy seems to be studying the eastern portion of Africa very carefully just at present; at least there are a large number of Italian voyagers in Shoa and Abyssinia this year. It is said that the object of their trip, commercial or political enterprises, forces them to remain quiet concerning all they observe, and therefore they have not published much. The names of some of these explorers are Antonelli, Martini, Piana, Ragazzi, Salembeni, Traversi, etc. Other travellers who have had secret missions have been able to impart valuable information to geographers without committing any indiscretions, as, for example, Captain Longbois, who has given a very attractive description of his voyage to Shoa where he visited King Menelik, and it is hoped that our Italian friends will soon follow his example.

Another very fatal portion of Africa is the extreme eastern part near the Red Sea and the Gulf of Aden. The list of those who have lost their lives in this region is quite long already, and this year we must add the massacre of the Italian expedition under Porro at Harar, also of that under Barral at Shoa, the death of Paul Sollellet, the French explorer, at Aden, as the result of the hardships of his trip to Kaffa and Shoa, and then the complete destruction of the crew of a French man-of-war in the Gulf of Tadjurah. In spite of all this the Italian voyager Franzoi will make an attempt to reach Kaffa and the great lakes by the way of Zanzibar, and is fitting out an expedition to make his proposed trip.

When the insurrection in Egypt under the Mahdi broke out Dr. Schnitzler (Emin Bey) was governor of the equatorial provinces, in the service of the Khedive, and was stationed at Lado. He was not only noted for his activity as an officer, but also as an explorer. This man, and those who supported him, were thus penned up, and for a long time no news came from them, for communication in the direction of Egypt was thus cut off. At the same time the state of affairs to the south and east was hardly less favorable. Between the Soudan and the Indian Ocean we find the kingdom of Ouganda, ruled over at present by Mwanga, a very unworthy successor to Mtesa, who always aided

the white men who passed through his realm. This latter tyrant however has either intercepted all the messages or killed the messengers sent to Emin Bey. He ordered the massacre of the caravan of the unfortunate English Bishop Harrington, to the east of Victoria Nyanza, near Kavirando, and seems determined that no one shall approach his state or pass through it. Dr. Fischer was prevented from going around Victoria Nyanza to aid the party of Emin Bey and they were not allowed to escape from the Soudan. The Khedive and the English authorities have ignored these indications of blind hatred, or they would not have turned this governor over to himself and left him to become the victim of their political mistakes. Fortunately Emin Bey did not lose his head in this serious state of things, but immediately joined forces with Dr. Junker, who has been exploring this region since 1879, and Captain Casati, who has been travelling along the Uelle,—the two other Europeans who were in the country. Their position at Lado was at first untenable and they retreated to the south with a handful of devoted men; since then reports have been received stating that Emin Bey made an aggressive move and had regained Lado. Dr. Junker then forced his way to the coast with messages from Emin Bey, in spite of the obstacles placed in his way by Mwanga, although at first he seemed to have been made a captive in Ounyoru. This distinguished explorer must have made many valuable observations during his long stay which will be very useful in completing our maps of this district. Expeditions are being fitted out for the relief of Emin Bey and Casati. The whole district about Lakes Bangweolo and Moero has been most thoroughly exhausted by the expeditions of Boehme, Reichard, and Giraud.

A new and easy route to the head of Lake Nyassa has been found by Pfeil, who has been traveling along the Ulanga, which is a large tributary of the Lufiji. Revoil left Zanzibar for Lake Tanganyika last year and only succeeded in reaching Tabora, about two-thirds of the distance to the lake.

The only important expedition between the coast and Lake Nyassa was that of Serpa Pinto and Cardoso, who were able to found the station of Blantyre, on the Shire, after several attempts.

Dr. Fischer, in spite of all his efforts to reach Dr. Junker, only succeeded in reaching Victoria Nyanza, and was unable to traverse Uganda or go around the lake, and there is no doubt but that the trials of this trip helped to bring about the premature death of this intrepid traveler at the age of thirty-eight. He died suddenly on his return to Berlin, November 11, 1886. There are some other prisoners in this Nyanza region who do not dare to move from Uganda without permission from the king, viz, the two missionaries, Mackey and Lomdel. The expedition under Livinhac is also detained at the south of the lake, waiting more favorable conditions to advance to the north.

A very rapid trip across the continent from Stanley Falls to Zanzibar was made by Glerup. He was materially aided by Tipu-tip, a



powerful chief, and passed through Nyangwe, then Ujiji, on Lake Tanganyika, then Bagamoyo, and reached Zanzibar in five months, making too quick a journey to add much to our geographical knowledge of the regions crossed.

Dr. Lenz, the famous explorer, who was sent to the aid of Dr. Junker, was detained at Stanley Falls by circumstances beyond his control until April, 1886, when he left for Nyangwe and Tanganyika. In the mean time Dr. Junker virtually became a captive, and the lot of Dr. Lenz has become a source of inquietude because he is doubtless completely in the power of Arabs hostile to Europeans. Dr. Lenz was accompanied by Dr. Baumaun and Bohndorff, the faithful companion of Dr. Junker. He seems to have given up the possibility of reaching the valley of the Uelle through that of the Mobangi (the connection only existing on some fancifully constructed maps). At first he intended traveling up the Aruwimi, but later news from the captives, which led him to believe that they were on the eastern side of Albert Nyanza, determined him to give the preference to the Mburu route.

The best and clearest résumé of the work of all investigators of the affluents of the Congo has been given in Petermann's *Mitteilungen*, 1886, ix and xi, by v. François. It embodies the work of Grenfell, Kund, Tappenbeck, Wissmann, Wolf, and himself, among others. The year has been rather poor in results as far as the basin of the main river Congo has been concerned. Many travelers have passed up the river as far as Stanley Falls, among them Lenz, Bove, v. Schwerin, etc., but nothing new has been pointed out. In January, 1886, Kund and Tappenbeck found that the Ikata enters the Kassai just before this latter river enters the Congo. There is still considerable doubt concerning the lower course of the Kwango, one of the main southern branches of the Congo, and it is to be regretted that the travels of Massari and Buttner do not throw any new light on the subject, because their itineraries agree and disagree in the most peculiar manner.

Lieutenants Kund and Tappenbeck have traveled over portions of the Kwango, Kassai, and Sankuru. They found two new tributaries of the Kwango, viz, the Wambu and the Saie, which latter empties into the Kuilu before it joins the Kwango. None of their guides would follow them beyond the Kassai, and on reaching the Sankuru with boats and travelling along it they turned eastward through prairies and dense forests. On their return they discovered a new and important river, the Ikatta, which reaches the Congo under the name of Mfui. This latter river Stanley believes is the outlet of Lake Leopold II.

Lieutenant Wissmann has descended the Kassai, and the result has been the complete revolutionizing of our previous ideas of its course. He has gone still further eastward to Lake Lanji, the great basin from which the Congo flows and into which the great rivers, the Lualoba, the Luapula, and the Lufira, empty.



In this connection it might be well to mention the fact that Grenfell and v. François have been travelling up the various tributaries, one after another, as far as their little vessel could go, and have been renaming them all.

The Kingdom of Muata Yamvo, so well described by Pogge, has been recently visited by de Carvalho on a political mission from Portugal, in which he is said to have been successful.

After a while we may get some definite idea of the limits of the regions of this continent, concerning which almost all the various nations of Europe have been contending. The International Boundary Commission have been having a difficult time locating the artificial limits of these so-called states, which are sometimes marked by problematical rivers. The members of the French Commission, Rouvier and Ballay, and those of the Congo Free State, ascended the Congo, trying to find the mouth of the Licona, which was to be the boundary according to the terms of the Berlin treaty. They reached the Bunga without finding the Licona, and here the delegates of the two states signed a declaration which states "that the Licona of the maps and of the treaty is nothing more than the Bunga."

French Congo has been explored by J. De Brazza, who passed down the Sekoli from a point near its source, for some distance, and then traveled to the north and eastward. They intended going down the river to its juncture with the Congo on their return, but the natives would not supply them with canoes. They made boats for themselves, and after a month's hard work reached the junction of the Sekoli and Ambili. Later along they reached the Congo, and then made their way back to the coast from Bunga station by way of the Alima and Ogowe.

In South Africa the only expedition now in the field is that of Dr. Holub. There have been many explorations in previous years which we are just commencing to hear from; for example, that of Capello and Ivens, which extended from coast to coast; that of Montague Kerr from Cape Colony to the Zambesi and Lake Nyassa; that of Schulze to Lake Ngami, and more recently that of Farini across the Kalahari Desert to Lake Ngami. A rather energetic and carefully-planned expedition to the Lower Niger and the Sokoto was made by Thomson last year. They steamed up these rivers as far as they could go, with their caravan already mounted, on board the vessel which carried them, and, when they could go no further, landed and were off before the natives knew what was going on or could recover from the surprise. Their object was to conclude treaties with the sultans of Hansa. Their promptness probably saved their lives, but all their papers and baggage were lost. The lower portion of the Niger is held by the English nation, who control all the commerce of this region from their station at the junction of the Niger and the Benue. A German station has been founded at Bakundi by Flegel, the explorer of the Torraha. The upper part of the river has been carefully explored by Davoust, for, although previously studied by

Caillé and Park, it was but partially known. For a long time Lake Liba has had a location and a name on the maps, but they have served as a sort of *ignis fatuus*, for it defies all attempts to reach it, if it exists, and this seems more problematical than ever in spite of the efforts of Rogozinski and Parsavant, who announced their intention of visiting it.

The northwest coast of Africa, never very hospitable, has been keeping up its reputation during the past year. The attempt of the German Commercial Geographical Society at Berlin to establish a station at Cape Nun came very near ending fatally to all concerned. The party were left on the shore, and after wandering in the most wretched condition from one tribe to the next, they were at last escorted to the coast at Mogador. There have been several expeditions across Morocco, and some from Algeria, and many errors and defects have been corrected in our maps. Many of the routes between the leading towns of this district have been shown to be practicable, but our map is far from complete. The work of Maurel, de la Martinière, Duveyrier, Foucault, and Quedenfeldt has been important for this reason, that their travels have made us better acquainted with a region of the globe which, though it is quite near Europe, has been virtually sealed to the white man by the fanaticism and ferocity of the natives. Thus the slopes of the Atlas Range, which are not so very distant from the coast, are almost an unknown region.

We have received what is probably an exaggerated account of Adrar from the Spanish expedition under Cervera which started from Rio di Ouro. They reached their destination nearly in a dying condition after many hardships and after being robbed of nearly everything, and consequently their picture of the region hardly agrees with that of Vincent and Panet, who describe it as a most delightful place, comparing it with the most favored portions of Switzerland.

Timbuctu is again exciting attention, and expeditions have started from north and south to reach this city. Among these might be mentioned the party under Gallieni and Viard along the upper course of the Niger. They were only forced to return by lack of water at Djenne. The party under Dr. Krause promises interesting results, because they travelled through regions as yet unexplored. We have to chronicle here the assassination of Palat, who left Algeria for this point and was treacherously murdered on the road.

The Cameroon region has been more carefully studied and explored since it has come under the German protectorate. Dr. Schwarz, Pauli, Langhaus, Zöller, Valdau, and Knutson have been the main explorers of the slopes of the mountains, while the many streams which enter the Atlantic from this range have been examined by the Government authorities. Schwarz, Valdau, and Knutson passed beyond the mountains, and describe the region visited as a fertile and pleasant one, and not a desert as was supposed. The mountains are described as peculiarly beautiful, with peaks reaching 12,000 and 13,000 feet.

More was expected from the trip of de Oca, Osorio, and Tradier in their trip to the Corisco coast, to the south of this region. They visited probably the most glorious portion of this western coast between the Campo and Mouni Rivers, but their descriptions are disappointing.

*North America.*—The only portions of North America which seem to be left for great geographical discoveries are Alaska and the central and western portions of British America. The work of the Coast Survey and the Geological Survey is rapidly giving us the detail of most of our vast western territory. Alaska alone seems comparatively neglected, except along the coast-line, on account of its peculiar position. The expedition sent out under Lieutenant Schwatka by the New York Times to the Mount Saint Elias Alps, visited that part of Alaska which is nearest the United States but which is least known, having been seen but once by the Coast Survey, in 1874, and then under disadvantages. The party succeeded in crossing the large glaciers which come from the great arc of mountains (of which Mount Saint Elias is the center) and which pass between the range and the coast. They ascended the lower slopes of one of the adjacent mountains, but did not reach the main slopes of the mountain.

On this same southern shore of the body of Alaska, Lieutenant Allen completed his explorations of the Copper River and the Tananah, the largest branch of the Yukon. Lieutenant Stoney has explored the western coast of Alaska between the Kowak River and Point Barrow, after wintering at Fort Cosmos, on Kowak River, which he discovered in 1883.

In central British America, Hudson's Bay has attracted most attention, on account of the proposed scheme of making Hudson's Straits the outlet for all the great grain districts to the south and west of the bay. Lieutenant Gordon has found that the straits are always open from July to October, which fact seems to encourage the promoters of the plan to compete in this way with our transcontinental railways. The whole affair appears to be very visionary, but may be carried out after all.

Our knowledge of Central America has been somewhat increased by the archæological voyages of Pinart to Chiriqui and of Charnay to Yucatan. We have also the details of the Nicaragua route between the two oceans.

*South America.*—This is a continent which still merits explorations, and those of the present year have been quite successful in disclosing many new features, though some of the expeditions have of course suffered. Beginning at the north, we find the expedition of Dr. Siewers in Venezuela is completed this year by a trip to the Sierra Nevadas of Santa Marta. He has now spent some three years in Venezuela, and all have been profitable.

The explorations of Tenkate in the Guianas have been resumed this year. He reached the State of Bolivar, on the Orinoco, then went to Cumana, the peninsula of Araya, and after this to La Guayra and Caracas. Here he suffered from fever to such an extent that he had to stop work.



A new scientific expedition has been in Venezuela this year, under the leadership of Chaffanjon, already well known by his explorations. The object of the expedition was to reach the headwaters of the Orinoco. After a stay in Bolivar, he set out with his companions, Morisot and four men engaged as rowers, but his men deserted him during the night, carrying off the canoe and some provisions. They secured a new crew of two men, at a high price, and worked themselves, in order to continue the trip. The floods had driven all game from the river banks, and they were thus deprived of meat in the way of food which hunting would have given them. For several days they were forced to live upon roots. They reached Caicara, the point where the Apure joins the Orinoco, and stopped there, overcome by hunger and fatigue. The swollen current of the river, greatly increased by the heavy rains, prevented their proceeding farther.

The South American continent has been crossed from east to west by two Europeans during the present year. Olivier (French consul to Callao) was the first to accomplish this feat. Starting from Callao he crossed the Andes and descended the main streams to the Atlantic coast, whereas Payer ascended the Amazon (Marañon-Ucayali), and then crossed the Peruvian Andes. He has prepared a map of many of the smaller tributaries which he explored. Both voyages have been the means of adding considerably to our knowledge of the geographical and hydrographic features of the central portion of South America.

A commission has been appointed by Brazil, Paraguay, and the Argentine Republic to explore that portion of the Argentine Republic which projects in between Paraguay and the Brazilian province of Rio Grande do Sul, with the object of determining the respective frontiers. Two preliminary voyages have been made here by Nederlein and Godio. Very little is known of this province, which has been called the Mission Territory because of the missions founded there by the Jesuits with the idea of civilizing the Indians.

Thouar is still actively engaged upon his explorations in the Argentine Republic and Bolivia. He had scarcely returned from his voyage on the Pilcomayo when he started out from Buenos Ayres to meet the Bolivian ambassadors at Tarija in order to consult as to the best way of opening the navigation of the Pilcomayo. It was his intention at first to go by the way of the Gran Chaco region once more, with some natives, but after careful consideration he decided to take the less dangerous route through Tucuman, Salta, and Jujuy. He was retarded by the rains and when he reached Tarija he did not find the ambassadors, as he expected, and he found that Bolivia was not in a condition to prove there was a practicable fluvial route to the heart of their country, by tracing the course of the Pilcomayo to the Paraguay. The hardships endured on this trip were remarkable. They were deserted by their men, and they often lost their way in the mountain labyrinths. Their burdens were heavy, and it is scarcely any wonder that the fatigue



of the trip under such conditions brought on fever which forced them to stop and rest.

The Argentine Republic has undertaken to explore the region between the Pilcomayo and the Vermejo, and has sent out an expedition under de Brettes, accompanied by Boisviers and Robin with an escort of twenty men. Viscount de Brettes has been in this region before, and therefore we may expect thorough work from his party.

Chili is at present engaged in the official exploration of the territory ceded by Peru after the war. The desert of Atacama is also being studied, and an expedition has been sent to Tierra del Fuego to examine the gold-bearing strata said to have been recently discovered there.

A real voyage of discovery has been made in Patagonia this year by Colonel Fontana, the governor of the Chupat Territory. His brilliant expedition to the eastern slopes of the Andes is to be followed by a minute exploration of the regions which he could only cross at a very rapid rate. All that is known of the beautiful valleys which lie at the foot of the Andes, beyond the desolate and arid Pampas, rests upon the descriptions of native hunters, because, with the single exception of the hasty visit of an English marine by the name of Musters, in 1869, no one has ever visited this region. The reality seems not only to answer the description, but to surpass all our conceptions of its possibilities. These valleys are said to be picturesque, fertile, and well watered, and form a complete contrast with the monotonous Pampas which must be crossed to reach them.

One expedition to Tierra del Fuego has been already noted. The Argentine Republic, which owns the other half of this region, has also sent out a mining expedition to exploit the recently discovered gold.

The distinguished geographer Lista is also travelling in Tierra del Fuego, and much that is valuable concerning this wild land can be expected from his report.

*Australia and Oceania.*—Lindsay, who explored the Arnheim peninsula in 1883, has crossed the Australian continent. He travelled from southern Australia toward Lake Eyre in order to study the course of the Finke River. He finds that in the rainy season it empties into the Treuer or Macumba River, which is the main northern tributary of Lake Eyre, but in the dry season it loses itself in the sand. From this point he went eastward to the Herbert River, which led him to the north, and he studied this river carefully, passing from it to the Arthur River, which carried him to the Gulf of Carpentaria, thus making his trip from the south to the north, across the continent, complete. New Guinea seems to have treated all explorers badly this year, the expedition of Forbes not even excepted. This party, fitted out with the greatest care for scientific work, intended to cross the Owen-Stanley mountains and explore the regions beyond. They were delayed in reaching the base of operations, and when they got there the season was so far advanced that the trip was given up for the time being, and the party

remained at Sogere, waiting for a favorable opportunity. Their means became exhausted, but not wishing to leave the island without at least seeing that part of it he came to explore, Forbes, accompanied by a Mr. Chambers, undertook a trip to the top of the Owen Mountains, but they were deserted by their guides, and were forced to regain the coast with all speed. They have returned to Australia in the hope of finding aid to enable them to undertake the trip once more.

Dallmann and v. Schlenitz have ascended the Empress Augusta River some 190 miles from its mouth.

The German expedition under Dr. Schrader has limited its explorations to the neighborhood of Port Finch, the capital of their colony of Kaiser Wilhelm's Land.

*Polar Regions.*—Lieutenants Ryder and Block have charge of the Danish expedition to Greenland. They expect to visit the coast from Upernavik to Melville Bay and are accompanied by the geologist Using. Captain Hovgaard has started out to reach 77° north latitude on the east coast at the same time, and the "Fylla" expedition has been examining the coast from the extreme southern point to Upernavik the last inhabited point to the northward.

Iceland has been crossed twice this year. Dr. Labonne has traversed the island from south to north in the central portion. On his way he ascended Mount Hecla, to which he assigns an elevation of 5,227 feet above the sea. Thoroddsen has been continuing the geological studies already begun in the northwestern portion of the island, and has reached Cape North.

There is a plan on foot for an expedition to Nova Zembla, the main object of which will be the measurement of the attractive force of the earth, but geographical explorations will also form part of their work. This effort is being made by Colonel Chamhorst.

The Liakof of Islands and the five islands of the New Siberia group have been visited by Bunge and v. Toll, who crossed the ice which unites these islands with the continent on sleds.

But one of the many expeditions planned to reach the North Pole has actually started. Colonel Gilder left Winnipeg for Hudson Bay with the idea of reaching the eastern coast of Baffin's Land from this place and then take a whaler if possible to Cape Sabine and winter there, after which he intended to start directly north for the pole. Colonel Gilder has returned to Winnipeg, having been unable to cross Hudson Bay on account of the lateness of the season. This expedition was sent out by the New York Herald.

A very interesting expedition is being organized for the exploration of the regions, somewhat neglected up to the present time, which lie around the South Pole. The impulse in this direction was given by the Australian Societies, and appears to have found an echo in England where active steps are being taken to secure the funds necessary for such an exploration.



## PHYSICS IN 1886.

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By GEORGE F. BARKER, M. D.

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### GENERAL.

The address of Professor Rowland upon "The Physical Laboratory in Modern Education," delivered at the tenth anniversary of the Johns Hopkins University, is an important contribution to the discussion now in progress as to the value of scientific methods in education. His ideal man has "full respect for the opinions of those around him, and yet with such discrimination that he sees a chance of error in all, and most of all in himself. He has a longing for the truth, and is willing to test himself, to test others, and to test nature, until he finds it. He has the courage of his opinions when thus carefully formed, and is then, but not till then, willing to stand before the world and proclaim what he considers the truth. Like Galileo and Copernicus, he inaugurates a new era in science, or, like Luther, in the religious belief of mankind. He neither shrinks within himself at the thought of having an opinion of his own, nor yet believes it to be the only one worth considering in the world; he is neither crushed with intellectual humility, nor yet exalted with intellectual pride; he sees that the problems of nature and society can be solved, and yet he knows that this can only come about by the combined intellect of the world acting through ages of time, and that he, though his intellect were that of Newton, can, at best, do very little towards it. Knowing this, he seeks all the aids in his power to ascertain the truth; and if he, through either ambition or love of truth, wishes to impress his opinions on the world, he first takes care to have them correct. Above all, he is willing to abstain from having opinions on subjects of which he knows nothing." To form such a mind, says Professor Rowland, is the province of modern education. "So far as I can see," he states, "the unscientific mind differs from the scientific in this, that it is willing to accept and make statements of which it has no clear conception to begin with, and of whose truth it is not assured. It is an irresponsible state of mind, without clearness of conception, where the connection between the thought and the object is of the vaguest description. It is the state of mind where opinions are



given and accepted without ever being subjected to rigid tests, and it may have some connection with that state of mind where everything has a personal aspect and we are guided by feelings rather than by reason." In attempting to correct these faults, it is necessary that we bring the mind in direct contact with some standard of absolute truth, and let it be convinced of its errors again and again. "Let the student be brought face to face with nature; let him exercise his reason with respect to the simplest physical phenomenon, and then in the laboratory put his opinions to the test; the result is invariably humility, for he finds that nature has laws which must be discovered by labor and toil, and not by wild flights of the imagination and scintillations of so-called genius." "To train the powers of observation and classification, let students study natural history not only from books, but from prepared specimens or directly from nature; to give care in experiment and convince them that nature forgives no error, let them enter the chemical laboratory; to train them in exact and logical powers of reasoning, let them study mathematics; but to combine all this training in one and exhibit to their minds the most perfect and systematic method of discovering the exact laws of nature, let them study physics and astronomy, where observation, common sense, and mathematics go hand in hand." Much of our modern education fails because it trains only the memory, using the reason and judgment merely to refer matters to some authority who is considered final. Worse than all, students are not trained constantly in applying their knowledge. "To produce men of action, they must be trained in action. If the languages be studied, they must be made to translate from one language to the other until they have perfect facility in the process. If mathematics be studied, they must work problems, more problems, and problems again, until they have the use of what they know. If they study the sciences, they must enter the laboratory and stand face to face with nature; they must learn to test their knowledge constantly, and thus see for themselves the sad results of vague speculation; they must learn by direct experiment that there is such a thing in the world as truth, and that their own mind is most liable to error; they must try experiment after experiment, and work problem after problem, until they become men of action and not of theory." "This, then, is the use of the laboratory in general education—to train the mind in right modes of thought by constantly bringing it in contact with absolute truth, and to give it a pleasant and profitable exercise which will call all its powers of reason and of imagination into play." "The special physicist trained there, must be taught to cultivate his science for its own sake. He must go forth into the world with enthusiasm for it, and try to draw others into an appreciation of it, doing his part to convince the world that the study of nature is one of the most noble of pursuits, that there are other things worthy of the attention of mankind beside the pursuit of wealth." (Science June, 1886, VII, 573.)

Joukowsky has made an elaborate mathematical investigation of the laws of motion of a solid body having hollows filled up with a homogeneous liquid. Various shapes of cavities were considered, as well as the case where there was vortex motion of the liquid, with interior friction. Some of the phenomena resulting from the interior motion of the liquid itself, in the case of the solid body, when caused to rotate, were verified experimentally and thus proved to accord with theory. These experiments showed that in a body whose rotation velocity decreases from the surface to the center (as, for example, a glass sphere filled with water while being put into motion) the molecules flow from the poles to the equator; while, on the other hand, when the rotation is suddenly stopped the speed decreases from the center to the circumference and the flow is from the equator to the poles. The general conclusion of the inquiry is that if we have a hollow body filled with a liquid, and if this system be put in motion, its motion will tend toward a limit determined by one of the principal axes of inertia of the body, taking the direction of the principal moment of the communicated motion, and the whole system will rotate about this axis as a single body, the speed of rotation being constant and equal to the quotient obtained by dividing the force applied by the moment of inertia of the system with regard to this axis. The author thinks that this result may explain the fact that the planets, notwithstanding the variety of their primary velocities, all rotate around their axes of inertia. (Nature, February, 1886, xxxiii, 349.)

Von Helmholtz has given to the Physical Society of Berlin a sketch of the "doctrine of the maximum economy of action," in connection with his own investigations in this direction. This doctrine was first propounded by Maupertius in 1744 in a treatise laid before the French Academy. This treatise, however, contained no general statement of the proposition, nor did it define the limits of its applicability, but only adduced an example. But this example in the present state of our knowledge is seen not to have been pertinent and not to have any relation to the principle of the *actio minima*. Two years later, Maupertius propounded his principle before the Berlin Academy, proclaimed it to be a universal law of nature and the first scientific proof of the existence of God. But on this occasion, too, he did not prove the proposition nor determine the limits of its applicability, but supported it by two examples, one only of which was correct. This principle, propounded with such grand solemnity, but so weakly supported, was violently attacked by König, of Leipzig, and defended just as keenly by Euler. This mathematician likewise failed to furnish the proof, which was not possible until after the investigations of Lagrange. The form in which the principle of the *actio minima* now exists was given to it by Hamilton, and the Hamiltonian principle for ponderable bodies is in complete harmony with the propositions of Lagrange. The elder Neumann, Clausius, Maxwell, and Von Helmholtz himself had already extended the Hamiltonian principle to electrodynamics. For this purpose, and

in order to be able to subordinate it to all reversible processes, the speaker had undertaken some transformations of it, and had introduced into it the conception of the "kinetic potential." In the form it has thus attained, the Hamiltonian law—the old principle of the *actio minima*—has in point of fact universal validity. It has just as wide an application as has the law of the conservation of energy and reveals a whole series of mutual relations between the different physical processes. (Nature, July, 1886, xxxiv, 308.)

Becker has propounded a theorem of maximum dissipativity, as follows: In all moving systems there is a constant tendency to motions of shorter period. And moreover if there is a sufficient difference between the periods compared, this tendency is always a maximum, so that all natural phenomena occur in such a way as to convert the greatest possible quantity of the energy of sensible motion into heat, or the greatest possible quantity of heat into light, etc., in a given time, provided that the interval of time considered exceeds a certain fraction of the period of the most rapidly moving particles of the system. From this it follows immediately that the higher forms of energy can be produced from the lower, or motions of longer period from those of shorter period, only on condition that the sum of the transformations of the system is equivalent to a degradation; a result nearly identical with one of the chief deductions from the second law of thermodynamics. (Am. J. Sci., February, 1886, III, xxxi, 115.)

Tait has undertaken a mathematical investigation upon the partition of energy between two systems of colliding spheres, because since 1860, when Clerk Maxwell published his first grand investigation on the subject, it seems to have been taken for granted than in a mixture of great numbers of colliding spherical particles of two kinds, the ultimate state would be one in which the average energy of translation is the same for a sphere of either kind. (Nature, January, 1886, xxxiii, 270.)

Exner has employed a new method for calculating the size of molecules. The Kinetic theory of gases gives the diameter of a molecule as a fraction of the mean length of free path and of the ratio of the space actually occupied by the material particles to their apparent volume. Clausius has obtained this latter value in terms of the dielectric constant; and since this is equal to the square of the refractive index, in terms also of this index. Hence, knowing the mean length of free path of the molecules of any gas (determined from diffusion or interior friction) and its index of refraction, the actual diameter of the molecules may be calculated. Exner's figures are as follows, expressed in centimeters. They should all be multiplied by  $10^9$ : Air 10,  $\text{CO}_2$  13, CO 13,  $\text{H}_2$  10,  $\text{CH}_4$  12,  $\text{C}_2\text{H}_4$  21,  $\text{NH}_3$  16,  $\text{H}_2\text{O}$  19, N 17, NO 16,  $\text{O}_2$  16,  $\text{H}_2\text{S}$  22, HCl 18,  $\text{SO}_2$  17,  $\text{C}_2$  19, and  $\text{C}_2\text{N}_2$  19. To this table the author has added the relative atomic volumes and relative specific weights of certain substances. By the latter is to be understood the weight in grams of one cubic centimeter filled with the molecules on



the supposition that there are no vacant spaces between them. (Anz. Ak. Wien, 1885-'87; J. Phys., May, 1886, II, v, 240.)

Mach and Wenzel have studied the mechanism of explosions with a view to explain their action in rupturing the solid bodies on which they are placed, even when the explosive is unconfined. The experiments were made with silver fulminate. The authors show, in the first place, that a visiting card is perforated quite as readily by the explosion of a small quantity of the fulminate placed upon it when the experiment is performed in vacuo as when it is made in the air, thus proving that the presence of air is not necessary to the result. In the next place they established the fact that the velocity of propagation of the explosive wave is very great by placing a few grains of the fulminate in the middle of a train of powder upon a sheet of paper. After ignition the direction in which the combustion was propagated through the powder could be clearly recognized, but the position of each mass of fulminate was marked by a circle with divergent striæ, equally distinct and well marked in all directions. Hence the combustion of the fulminate had not occupied an appreciable time. To measure this velocity of the combustion in the case of the fulminate, the authors laid two parallel trains of fulminate upon a strip of paper and fired them at opposite ends simultaneously by the spark of a Leyden jar. Above these trains was a plate of smoked glass, upon which after the explosion an oblique interference band could be seen, making with the trains themselves an angle  $\alpha$ . If  $c$  be the velocity of sound (supposed with these wreat amplitudes to be not less than 400 meters), then  $\sin \alpha = \frac{c}{v}$  from which  $v$ ,

the velocity desired, can be calculated. This the authors found to be between 1,700 and 2,000 meters per second. In further proof of the extremely brief duration of the explosion, a ballistic pendulum was attached at its top to a horizontal rod, upon the end of each arm of which was a card. On firing a small discharge of fulminate upon one of these the card itself was perforated, but no impulse whatever was given to the pendulum, the velocity of propagation of the explosive wave being too great to communicate any motion to the mass in the time the combustion occupied. If however the cards be replaced by brass cups the metal is not perforated, but the pendulum receives a strong impulse. If it be assumed that in this case the amount of motion corresponding to the lower half of the wave has been communicated to the pendulum, this amount can be calculated from the impulse given to the pendulum, and so an approximate value of the velocity of this wave obtained; but the value thus calculated is too great. Hence it seems probable that the wave is reflected by the metal without diminution of strength. In this case the amount of motion communicated to the pendulum is twice that of the half wave, and the calculated velocity on this supposition is reduced to one half or to 1,750 meters per second. (Wied. Ann., 1885, xxvi, 628; J. Phys., November, 1886, II, v, 477.)



Wolf has presented a paper to the French Academy on the authenticity and exact value of the Peruvian unit of length preserved in the Paris Observatory. Since the French legal meter is defined as a determined fraction of this standard unit taken at the temperature of  $13^{\circ}$  Réaumur, the importance of ascertaining its exact value and its state of preservation is obvious. Moreover, as the same standard was used for the measurement of an arc of the meridian in Peru, it forms the connecting link between the older and the more recent geodetic operations. For these reasons, this meter has become an object of the highest interest, not only for France but also for the whole scientific world. The author replies in detail to the doubts and objections raised by Peters and others in Germany against its authenticity and state of preservation; and at his request a committee was appointed by the academy consisting of Faye, Mouchez, Janssen, F. Perrier and Wolf, to consider the whole question. (*Nature*, March, 1886, xxxiii, 503).

A paper on the normal meter has been presented to the Berlin Physical Society by Pernet. After a brief historical introduction, the paper discusses the events which in 1878 led to a new international agreement, in consequence of which a new normal meter of platinum-iridium of x form was prepared and compared with the meter of the archives. The paper describes minutely the arrangements of the Bureau in which the comparisons were undertaken, the contrivances for securing the several comparing rooms against outward disturbances, the means adopted for insuring constant temperatures, and the methods employed in the comparisons as also in the determinations of the expansion-coefficients of the rods used. His own especial labors had for their object the comparison of a series of normal meter rods of different metals with the meter of the archives and the determination whether repeated heatings and coolings between  $50^{\circ}$  and  $0^{\circ}$  C., whether concussions, and whether time caused any perceptible changes in the lengths of the rods. As the result of these investigations it was found (1) that the compared national standards, together with their divisions, were exact up to one-thousandth of a millimeter; (2) that, with the exception of steel (which on account of its changes in hardness, readily yielded modifications of volume and length in the rods made of this material), all the metals out of which the standards were made—namely, platinum-iridium, platinum and brass—furnished material suitable for normal meter rods; and (3) that repeated heatings and concussions induced no changes passing beyond the limits within which observation fails. (*Nature*, May, 1886, xxxiv, 22.)

The ninth report of the Comité International des Poids et Mesures has been issued. During the year 1885, new instruments have been obtained at a cost of about \$2,500, for the accurate comparison of standards of the metric system. These include a comparator for length measurements made by Brunner; mercurial thermometers, by Tonnelot; an air thermometer, by Golaz; a spherometer, by Brunner, and other measuring

instruments by Oerthing, Boudin, Alvergnyat, Simmon, and the Société Genevoise. During the year the director has verified the lengths and expansion coefficients of several standard meters, and has determined the weights and specific gravities of several standard kilograms for different governments and scientific authorities. The results of the comparison of the new kilogram prototype with the old kilogram des Archives are given and also a report on the verification at Paris of certain British standards. (*Nature*, May, 1886, xxxiv, 79.)

Mayer has described a modified form of spherometer, which he calls the well-spherometer, which is especially adapted to measure the radii of curvature of lenses of very small linear aperture. The novel feature of the apparatus is the well, a cylindrical aperture into which the screw of the spherometer passes. Placing a piece of flat glass against the lower opening of the well (which is for this purpose screwed into a flat plate resting on three feet), a reading of the instrument is made. Replacing the flat glass by the lens to be measured, which obviously must not be smaller than the aperture of the well, a second reading is taken. Then, knowing the radius of the well, an easy calculation gives the radius of curvature of the lens. Several very ingenious modifications of the apparatus are also described in the paper. (*Am. J. Sci.*, July, 1886, III, xxxii, 61.)

In a memoir to the French Academy, Germain has given the results of very accurate determinations of both the astronomical and the geodetic co-ordinates at Nice, St. Raphael, Toulon, and Marseilles, made for the purpose of studying the deviation from the vertical produced by the action of topographic relief of the surface. It follows from these four determinations that on the south coast of France the continent attracts the vertical, that is to say, it repels the astronomical zenith relative to the geodetic zenith. The effect is the same as if the attraction was exerted by a point situated to the northward of Nice, in the mass of the Alps.—(*C. R.*, May, 1886, cii, 1100.)

Deprez has suggested the employment of electricity for recording the oscillations of a pendulum. To the pendulum is attached a screen furnished with a slit. The light from a petroleum lamp, passing through this slit at each oscillation, falls on a linear thermopile and generates an electric current. This may be used to move the needle of a galvanometer, which acts as a relay and brings in an auxiliary current to operate a suitable recording instrument. (*C. R.*, June, 1886, cii, 1523.)

A paper on the dynamics of bicycling was read before the Dublin University Experimental Science Association by Gerald Stoney. In conjunction with his father, G. Johnstone Stoney, he had made experiments to determine the energy necessary to propel a bicycle. They found that when the velocity was 9 miles an hour, it required about 5,500 foot pounds per minute, and that it often rose higher than 10,000 foot-pounds per minute, the highest the apparatus was capable of recording. Their results on the power which a man can exert were higher

than those of other experimenters. This shows that the bicycle or tricycle is probably the most economical way of using human muscles. The experiments were made by attaching an indicator diagram apparatus to the lever of the safety bicycle known as the "Extraordinary," and also by observing the reduction in speed due to friction when the bicycle was running free. The experiments also showed that the resistance varied almost as the velocity, and that the pressure on the pedal was not constant, but was a maximum at the center of the stroke. (Nature, March, 1886, xxxiii, 455.)

Curie has contrived a transmission dynamometer having an optical measuring device. An arbor, supported horizontally upon two bearings, carries a pulley at each end, one of which receives the power and the other transmits it to the machine. The power transmitted is determined from the torsion of the arbor. This arbor is a metallic tube whose ends are closed by two plates of quartz cut parallel to the optic axis, and each giving a difference of half a wave length between the ordinary and extraordinary rays. A beam of polarized monochromatic light traverses the arbor along its axis, the plane of polarization being rotated through a definite and invariable angle by the quartz plates. If, however, any torsion of the tube is produced, the plane of polarization is rotated through twice the torsion angle. By a preliminary experiment, the couple of torsion necessary to produce a rotation of  $1^\circ$  is determined. Calling this  $c$ , and the angle of rotation of the arbor  $\alpha$ , the power transmitted per second will be represented by  $2, \eta, c, \alpha, n$ , in which  $n$  designates the number of revolutions per second. (C. R., July, 1886, ciii, 45.)

## MECHANICS.

### 1. *Of solids.*

Nipher has published a paper on the isodynamic surfaces of the compound pendulum. As is well known, certain particles in the system constituting such a pendulum tend to increase its acceleration, while others tend to diminish it. These two groups of particles are separated by a surface, such that no particle lying in it has any tendency at a given instant to change the acceleration of the system. It is in this surface that the axis of oscillation always lies. On either side of this neutral surface there must exist surfaces of equal tendency—isodynamic surfaces—those on the one side having a plus sign and those on the other a minus sign. Investigation shows these isodynamic lines for a disk pendulum to be concentric circles, their common center being on a horizontal line through the axis of suspension and at a distance from it, depending on the length of the pendulum (*i. e.*, the distance between the axes of suspension and oscillation, respectively), and on the angle of displacement, being half the length of the pendulum when it is horizontal and infinite when it is vertical. These circles are the right



sections of co-axial cylinders representing the isodynamic surfaces of any compound pendulum. (*Am. J. Sci.*, January, 1886, III, xxxi, 22.)

In determining density by means of the balance, it is desirable to know to how many decimal places the division should be carried when the error of weighing is the  $n$ th part of a gram. Lermantoff has investigated this question. Differentiating the ordinary expression for the density  $D = \frac{P}{Q}$ , we have  $dD = \frac{dP}{Q} - D \frac{dQ}{Q}$ . Hence (1) an error of a

certain fraction of a gram in the determination of the weight of a body produces in the density obtained an error equal to the same fraction of unity divided by the number of cubic centimeters occupied by the body; and (2) the influence of an equal error in the determination of the weight of water displaced is  $D$  times greater than that above given and of contrary sign. (*J. Soc. Phys. Chim. Russe*, 1885, xvii, 56; *J. Phys.*, February 1886, II, v. 91.)

Parize has suggested the following method of determining the density of porous friable bodies, such as earth, peat, and the like. A jar of 250 cubic centimeters capacity is exactly filled with a smooth, regular seed, such as linseed, for example, and is then weighed. The peat or other porous material is placed in the jar and shaken down to its normal condition, and the jar is again weighed. Knowing the weight of water required to fill the jar, all the data necessary to calculate the density are obtained. (*J. Phys.*, May, 1886, II, v, 222.)

Kirchhoff has calculated the change of form which an iron sphere would undergo under the influence of a constant magnetic force. Calling  $n$  the number of turns of wire in the magnetizing spiral and  $i$  the current in ampères which traverses it, he finds for the elongation of the radius of the sphere parallel to the axis of the spiral the value  $n^2 i^2 \cdot 2 \cdot 32 \cdot 10^{13} \cdot R$ . The contraction in a direction perpendicular to this axis is between one-fifth and one-sixth of this. (*Wied. Ann.*, 1885, xxiv, 52; xxv, 601; *J. Phys.*, 1886; April, II, v, 175, 179.)

Koch has published an account of experiments on the elasticity of ice, made by him in Labrador in 1882-'83, and in Fribourg in 1884. The co-efficient was determined from the flexure of bars of ice when supported at the ends and weighted in the middle. The principal difficulties encountered arose, first, from the direct evaporation which took place, and which changed the dimensions of the bars; second, from the plasticity of the ice, which produced a permanent and progressive set; and third, from the existence of a considerable residual elasticity. Allowing for these perturbing causes, the author obtained for the mean value of the elasticity co-efficient, for ice cut parallel to the free surface of solidification, the value 641.5, expressed in kilograms per square millimeter; a value considerably higher than that obtained by Reusch by the acoustic method, which was only 236.3. Koch, however, obtained a still higher value by the acoustic method, namely, 884 kilograms



per square millimeter. (Wied. Ann., 1885, xxv, 438; J. Phys., November, 1886, II, v, 484.)

Schneebeils has experimentally verified the conclusions of Herz concerning the impact of elastic bodies. The duration of the contact of two spheres 70<sup>mm</sup> in diameter was determined by the impulse given to a galvanometer needle by a current which passed between the spheres while they were in contact. Provided the total resistance of the circuit is large and the coefficient of self-induction small, the time may be considered proportional to the deviation of the needle. With velocities varying from 156<sup>mm</sup> to 1,032<sup>mm</sup> the deviations observed varied from 59.0 to 39.5, the product of the deviation and the fifth root of the velocity being sensibly constant. With spheres of different diameters and the same velocity the ratio of the diameter to the deviation was found to be constant. In order to determine the absolute duration of the contact, the author compared the impulse produced by the impact with that given by a pendulum sliding on a steel band during 0.00082 second, and thus obtained 0.000185 second. He has verified also the formula of Herz, which gives the radius of the surface of flattening in terms of the radius of the sphere. The spheres were covered with paraffin and the radius of the circle produced by the impact was measured micrometrically. For a velocity of 259<sup>mm</sup> the radius observed was 0.66<sup>mm</sup>; that calculated being 0.65. For a velocity of 518<sup>mm</sup> the radii were 0.83 and 0.85, respectively. For 1,042<sup>mm</sup>, 1.10 and 1.12<sup>mm</sup>, and for 1,535<sup>mm</sup> velocity, 1.31 and 1.27<sup>mm</sup>. In the case of the higher velocities, these results are interesting, since the pressure obtained surpasses that ordinarily assumed as the limit of the elasticity of the steel. (Arch. Sci. Phys. Nat., Geneva, 1885, xiv, 435; J. Phys., June, 1886, II, v, 291.)

Tomlinson has communicated to the London Physical Society the results of a long series of experiments on the torsional elasticity and the internal friction of metals, in the course of which he had noticed several sources of error incident to torsional experiments. In the earlier experiments a horizontal brass bar was suspended by a wire and oscillated, the time of vibration being observed by means of a lamp, scale, and mirror. Its moment of inertia was varied by sliding two brass cylinders, suspended from the bar by fine wires, backward or forward along it. Under certain conditions it was observed that the bar executed a few vibrations of gradually decreasing amplitude, came to rest and then commenced to swing again, the amplitude increasing to a maximum, then decreasing, and so on. This effect was finally traced to an approach to synchronism between the time of oscillation of the bar and that of the small cylinders about their axes of suspension, the absorption of energy being due to these being set in vibration. On clamping the cylinders rigidly to the bar the phenomenon disappeared. Subsequently something of the same kind appeared which turned out on investigation to be due to an approach to synchronism between the torsional and the pendulous vibration periods. Of course this could

not occur if it were practically possible to have the axis of the wire pass accurately through the center of mass of the vibrator. Another error arises from the fact that in a wire recently suspended the torsional vibration period is always slightly greater than when the wire has been long used and frequently oscillated (*Phil. Mag.*, November, 1886, V, XXII, 414; *Nature*, July, 1886, XXXIV, 283.)

Barns and Strouhal have continued in the laboratory of the U. S. Geological Survey their researches upon the effect of temper upon the structure of glass and steel, and have published: "A note on the structure of tempered steel," "Strain-effect of sudden cooling exhibited by glass and steel" (two papers), "Note on the hydro-electric effect of temper in case of steel," and on "The viscosity of steel and its relations to temper." (*Am. J. Sci.*, May, June, 1886, III, XXI, 386, 439; September, October, December, 1886, III, XXXII, 181, 276, 444.)

Lehmann has observed certain remarkable spontaneous changes of form in solid crystalline bodies, produced evidently by their interior forces. These changes were observed with the microscope and in the following substances: Quinohydrodicarbonic ether, protocatechic acid, and ammonium chloride. The first of these substances, for example, dissolved by the aid of heat, in aniline thickened with a little resin, crystallized in leaflets which are parallelograms of  $44^\circ$ . But on gradually lowering the temperature, these crystals change into others having a pale green color and angles of  $60^\circ$ . This change may commence at different points in the same crystal even, and so twist them, the movement at the ends of the crystal having force enough to displace the entire mass. The other bodies mentioned show the same property. (*Wied. Ann.*, XXV, 173; *J. Phys.*, November, 1886, II, V, 479.)

Fouqué and Lévy have experimented to determine the velocity with which vibrations are propagated through the ground. In their preliminary experiments the vibration was produced by the fall of a steam-hammer of 100 tons, at the Creusot works. The transmitted vibrations were observed by means of a mercury surface; their arrival, as well as the instant of fall, electrically transmitted, being registered by hand on a revolving cylinder. At 1,200 meters distance the jar produced by the blow ceases to be perceptible directly to the senses but is distinctly seen in the mercury. In the permian sandstone of Creusot, a velocity of 1,200 meters per second was recorded, in a direction parallel to the strata and 1,050 meters at right angles to their direction. The duration of the disturbance was nearly a second. At Meudon, where the terrace is formed of a thick layer of Fontainebleau sand, the propagation of the vibration is much less rapid, 320 to 360 meters only per second. But the duration of the disturbance was much longer, being about 5 seconds at 500 meters and  $3\frac{1}{4}$  seconds at 250 meters. Subsequently the authors employed an apparatus constructed by Breguet, in which a sensitive gelatino-bromide plate was made to turn about a beam of light reflected from the mercury bath. A shutter opens automati-

cally by an electric current upon the arrival of the vibration and begins the exposure, closing again before the plate has made a complete revolution. The registration attained is accurate to one twentieth of a second. With this apparatus experiments were made in the permian sandstone of Creusot, the granite of Montvicq near Commentry, and the carboniferous sandstone of Commentry; in the latter case in the mines, beneath the surface of the ground. The results show: (1) The velocities of propagation are greater than by the old method; (2) the disturbances caused by charges of powder or dynamite (up to 12 kilograms of the latter) are, at equal distances, less than those produced by the steam-hammer, falling through 5 meters; but even this at 500 meters produced hardly more effect than stamping with the heel did at 10 meters; (3) at the surface the shocks are multiple, enduring ten seconds at the distance of 1,200 meters; but beneath the surface there is but a single shock and that of short duration, whether the mercury is in the mine or at the surface. (C. R., Feb., June, 1886, CII, 237, 1290.)

## 2. *Of liquids.*

Joly has suggested a simple method of finding the specific gravity of small, heavy bodies. The substance, which may have a weight of only a few milligrams, is melted into some paraffin of known specific gravity in a small dish. The paraffin and substance are then floated in a specific gravity solution, and from the data thus obtained the specific gravity of the substance can be calculated. It is especially useful for porous bodies. (Nature, March, 1886, XXXIII, 455.)

Handl has proposed to determine the density of a liquid by measuring, by means of a water manometer, the hydrostatic pressure which it exerts at a given distance from its free surface. (Anz. Ak. Wien., 1885, 148; J. Phys., May, 1886, II, v, 241.)

Amat has devised a density pipette for taking the specific gravity of liquids. It consists of a straight glass tube, graduated, to the upper end of which is attached laterally a V-tube, also graduated on both limbs. The standard liquid is placed in this V-tube and by means of a rubber spherical cap on the upper end of the pipette the given liquid may be drawn into the main tube. Noting the height of this column, and comparing it with the difference of level in the standard column, the specific gravity of the given liquid may be read off in terms of the standard. A small correction may be made for capillarity. The results are accurate. (Bull. Soc. Chim., May, 1886, II, XLV, 482.)

If a rectangular glass vessel filled with water is penetrated at bottom by a tube connected by means of a tap with a lateral reservoir, containing water colored with aniline, and the whole is at the uniform temperature of the room, there is produced, when the tap is opened, a red jet in the middle of the colorless liquid. By modifying the orifice, and by placing within the liquid articles of various forms against which the liquid jet may impinge very varied phenomena are produced, which



were first observed by Oberbeck, and studied more recently by Kötschan. If the vertical jet for example strikes the center of a disk in the form of a regular polygon, the reflected jet divides into as many liquid sheets as there are sides to the polygon. These sheets are at first inflected as they leave the disk, but then recurve themselves, forming volutes of great elegance directed toward the interior of the polygon. The memoir is illustrated with numerous plates (*Wied. Ann.*, 1885, xxvi, 530; *J. Phys.*, November, 1886, II, v. 479.)

Thomson and Newall have studied the formation of vortex rings by drops falling into liquids. When a drop of ink falls into water from not too great a height it descends through the water as a ring, in which there is considerable rotation about the circular axis passing through the centers of its cross-sections. The drops were observed by instantaneous illumination; and it was seen that the drop enters the liquid as a sphere, becomes flattened as it descends, and finally breaks into a ring more than half an inch below the surface. To avoid complication drops were let fall into liquids of the same kind. These liquids were found to arrange themselves into four classes, distinguishable by the character of the ring formed, and also by the ratio of the coefficient of viscosity to the density. In Class I, ether, chloroform, and carbon disulphide gave rings only very uncertainly, the drop breaking up and spreading irregularly through the liquid. The ratio is not in this class greater than 0.7. To Class II belong water, alcohol, turpentine, paraffine, etc. These have the ratio between 1 and 3, and give the best rings. For Class III the ratio is between 3 and probably 8 or 10. This class includes moderately viscous liquids, such as butyl alcohol, amyl alcohol, fairly strong sulphuric acid, and diluted glycerine. Class IV includes all the most viscous liquids like strong solutions of sugar, potash, sulphuric acid, glycerine. The ratio has a value of 15 to 30, and no ring is formed at all unless special precautions are taken to get large drops. Capillarity plays no essential part in these phenomena. (*Nature*, February, 1886, xxxiii, 356.)

Vautier has applied a graphic method to the direct measurement of the velocity of efflux of liquids. In the flat, horizontal bottom of a cylindrical vessel full of water is an orifice in a thin plate, for which an ajutage can be substituted. Inside the vessel and in the line of its axis is placed a tube containing an emulsion of an insoluble liquid of the same density as water. This liquid is a mixture in suitable proportions of nitrobenzine and oil of turpentine. The very fine bubbles of this emulsion pass along the axis of the jet, of which they take the exact velocity. The image of the jet, and therefore that of the bubbles, is formed on a photographic plate, which by means of a suitable mechanism is made to move at right angles to the trajectory of the jet. The plate is exposed when the liquid begins to flow, so that it receives the image of the jet during its passage. The plate, when developed, shows one or more lines, according as one or more bubbles have passed during



the time of exposure. These lines are oblique, their direction being made up of two rectangular motions, that of the plate and that of the bubble. The velocity of motion of the plate is fixed by the vibrations of a tuning-fork, and the exact direction of its motion by a dotted line. Knowing the angle which one of the slanting lines in the photograph makes, the velocity of the bubble, and so that of the jet, may be readily deduced. (C. R., January, 1886, CII, 165; Phil. Mag., March, 1886, V, XXI, 285.)

Subsequently Vautier employed a rotating mirror for the same purpose. The jet as before flows vertically downward and its image is thrown on the screen by means of a lens; between the lens and the screen is placed a plane mirror movable about a vertical axis. As the bubbles fall vertically, the moving mirror causes a horizontal displacement in its image; so that upon the screen an inclined line is seen, the resultant of the two rectangular component velocities. The tangent of the inclination angle is the ratio of these velocities. His results confirm Torricelli's law to within one-eightieth part—(C. R., August, 1886, CIII, 372.)

Amagat has adopted the principle of the differential manometer for measuring very high pressures, the necessary conditions being that the pistons be completely mobile and at the same time perfectly tight. The large piston rests on a cushion of castor-oil which transmits the pressure to the mercury. The small piston which receives all the pressure at the top becomes quite tight if after being soaked in oil and put in its place it is wetted on its base with a sufficiently viscous liquid, such as molasses, which answers perfectly. Under these conditions, the pistons even being somewhat free, there is no real leak but only an extremely slow oozing which does not affect the measurements even up to pressures above 3,000 atmospheres. The water was compressed in a steel cylinder 1.2 meter long, hooped for its entire length except a part of the breech. Its diameter was 3 centimeters and its sides were 8 centimeters thick. The reading of the volume of the compressed liquid was effected by means of platinum wires fused into the stem of the piezometer, by means of which the current from a battery reaches the mercury in the steel cylinder. The precise moments at which the mercury rising in the stem reaches the platinum wires successively, as the liquid suffers compression, are thus noted on the galvanometer. The following are the coefficients of compressibility for water at  $17.6^{\circ}$  and for ether at  $17.4^{\circ}$ : For water between 1 and 262 atmospheres, 0.0000429; between 1,334 and 1,784 atmospheres, 0.0000302; and between 2,590 and 2,981 atmospheres, 0.0000238; at 3,000 atmospheres therefore the volume of water is diminished by one-tenth and its compressibility coefficient by one-half. For ether between 1 and 154 atmospheres, 0.000156; 870 and 1,243 atmospheres, 0.000063; and between 1,623 and 2,002 atmospheres, 0.000045. (C. R., August, 1886, CIII, 429; Phil. Mag., October, 1886, V, XXII, 384.)

Koenig has calculated the coefficient of interior friction for several liquids at a mean temperature of about  $18^{\circ}$ , from comparative experiments made by Maxwell's method of oscillating disks, and by the method of flow through capillary tubes. Ether gave by the former method 0.00274 C. G. S. units; by the latter, 0.00256; carbon disulphide, 0.00451 and 0.00388; light benzine, 0.00627 and 0.00627 and 0.00523; heavy benzine, 0.00862 and 0.00688; distilled water, 0.01587 and 0.01096; and turpentine, 0.02836 and 0.01865. Hence the former method gives somewhat higher results than the latter, and moreover the differences increase with the coefficients. (Wied. Ann., xxv, 618; J. Phys., November 1886, II, v, 486.)

Ayrton and Perry have communicated to the Physical Society of London a paper upon the expansion produced by amalgamation. They find for example that the amalgamation of brass is accompanied by a great expansive force. If one edge of a straight thick brass bar be amalgamated it will be found that in a short time the bar is curved, the amalgamated edge being always convex and the opposite edge concave. The authors suggest that a similar action may be the primary cause of the phenomena presented by the Japanese "magic mirrors." Japanese mirrors are made of bronze and have a pattern cast upon the back; and although to the eye no trace of it can be discovered upon the polished reflecting surface, yet when light is reflected from certain of these mirrors on to a screen the pattern is distinctly visible in the luminous patch formed. This is due to the polished side opposite the thinner parts of the casting being more convex than the others, a conclusion verified by the fact that the pattern is reversed when formed by a convergent beam of light. Such a condition of things would evidently result from a uniform expansive stress taking place over the reflecting surface, the thinner—and consequently the weaker—parts becoming more convex or less concave than the others. Hitherto this inequality of curvature has been attributed to a mechanical distortion to which the mirrors are intentionally submitted during manufacture to produce the general convexity of the polished surface; but the authors now think it possible that the use of a mercury amalgam in the process of polishing may have an effect in the production of this inequality of curvature. (Nature, April, 1886, xxxiii, 575; Phil. Mag., October, 1886, V. xxii, 327.)

Warburg and Ilmore have experimented to determine the cause of the layer of water which forms on glass and other bodies. They find: (1) That above the dew-point no weighable deposit of water could be detected on bodies with smooth surfaces, insoluble in water, such as platinum, glass with a coating of silica, glass free from alkali. Had the thickness of such a layer exceeded one or two millionths of a millimeter, the balance was sensitive enough to have detected it. (2) That the film of water which forms on alkaline glass above the dew-point arises from a small quantity of free or loosely combined alkali on the

surface of the glass. It must absorb water until the vapor-pressure above the solution of alkali is equal to that at the place of the experiment. (3) That this deposit on alkaline glass, which can be weighed, is the cause of the electrical surface conductivity which such glass shows in moist air when tried by the electroscope. Any glass which showed no weighable deposit of water with the balance in question was found to be a good insulator when tested by the electroscope. (4) That rock-salt showed a deposit of moisture some millionths of a millimeter in thickness, at temperatures for which the vapor-pressure was greater over a saturated solution of sodium chloride than the pressure in the place of experiment. There was, however, in the rock-salt used a small quantity of magnesium chloride, which would attract moisture, also, until the vapor-pressure over its solution was equal to the vapor pressure in the place of experiment. (Wied. Ann., 1886, No. 4; Phil. Mag., May, 1886, V, XXI, 452.)

Bunsen has analyzed the glass fibers used in his apparatus for the condensation of carbon dioxide gas upon the surface of glass, and which he had already proved to contain moisture. The analysis showed the concentrated carbonic-acid solution forming these capillary layers to have attacked the glass very decidedly; 49.543 grams of glass fiber yielding to cold water sufficient sodium carbonate to give 0.8645 grain sodium chloride when evaporated with hydrochloric acid. It further appeared that during the course of the experiment one hundred and nine days, 5.83 per cent. of the glass had been decomposed. However, only two-thirds of the observed absorption can thus be accounted for, but it is evident, notwithstanding the residuum, that glass is not a suitable material with which to try experiments on capillary absorption. (Wied. Ann., 1886, XXIX, 161; Phil. Mag., December, 1886, V, XXII, 530.)

The subject of capillarity and surface tensions has received considerable attention. Sir William Thomson has discussed the phenomena of capillarity experimentally in a lecture delivered at the Royal Institution (Nature, XXXIV, 270, 290, 366). Magie has determined the capillary constants of several liquids by means of a method suggested by von Helmholtz, which consists in deducing the radius of curvature of the capillary surface, in a tube of small diameter, from observing the image of a small linear object produced by this surface. For mercury, he obtained the mean value 45.82; distilled water, 7.226; carbon disulphide, 3.240; olive oil, 3.235; turpentine, 2.726; chloroform, 2.438; petroleum, 2.441; alcohol, 2.214 (Wied. Ann., XXV, 421). Reinold and Rücker have made a careful comparison of the surface tension of black films (*i. e.*, those thin enough to show the black of the first order of Newton's colors) with that of colored films whose thickness was from ten to one hundred times greater. They conclude that when the black part of a soap-film forms in the normal way, spreading slowly over the surface, no evidence of any change in surface tension dependent on the thickness of the film is furnished by a direct comparison of the tensions



of thin and thick films over a range of thickness extending from 1,350 to 12 millionths of a millimeter (Nature, June, 1886, xxxiv, 160). Magie has also determined the capillary constant from a formula of Poisson which gives its value as equal to the square root of twice the surface tension divided by the specific gravity. The formula contains, besides this constant, the height of the summit of the drop above the plate, the radius of the greatest section of the drop and the contact angle between the drop and the plate. Since the formula holds for an air-bubble formed in a liquid under a level plate, the author has made the necessary measurements upon such a bubble, and has obtained for the capillary constant of water 15.067 at 20°, absolute alcohol at about 14°, 5,764; olive oil at 18°, 7,410; and petroleum (sp. gr. at 16°, 0.808), 6,755 at 15° (Am. J. Sci., March, 1883, III, xxxi, 183). Duhem has shown that in order to treat properly the subject of capillarity and to bring the investigations of Thomson on the connection between changes of temperature and changes of the capillary surface into accord with the older ones, the ordinary mechanical treatment must be abandoned and general thermo-dynamical methods adopted. He shows, first, that for a system of bodies touching each other the potential is not to be sought at a fixed temperature, but the thermo-dynamical potential, which contains the changes of energy for varying temperature. Assuming that the densities and the actions of the molecular forces of bodies vary only in infinitely thin surface layers, this supposition is sufficient to prove that the thermo-dynamic potential consists of two parts, one of which is a linear function of the content of the various bodies, the other a linear function of the surface in contact. From the formulas obtained the laws of Gauss and Laplace for the shape of the surfaces are explicitly deduced. (Beiblätter d. Phys., x, 330; Phil. Mag., August, 1886, V, xxii, 230.)

### 3. *Of gases.*

In an extended experimental memoir on the law of gaseous flow, Hirn has given the results of investigations made to determine whether a gas under a constant pressure flows into a reservoir where the pressure also constant is less than its own, with a velocity indefinitely increasing as the pressure in the reservoir decreases; or whether there exists a limiting velocity which is attained when this second pressure is zero. Representing graphically the results of the experiments, it appears that the maximum value to which the volume-equations point has no existence, and that so far as the velocity of flow is concerned the limiting value indicated by Weisbach's equation equally has no foundation in fact. Hence it would seem that the true law of gaseous flow produced by pressure-difference is yet to be discovered. Moreover, the author calls attention to the discrepancy between his results and those predicted from the Kinetic theory of gases. According to this theory, dry air cannot, under a constant pressure, flow into a perfect vacuum with



a velocity greater than that of the gaseous molecules themselves at that temperature, about 485 meters per second. But in the experiments now made, even with a notable counter-pressure, velocities of 6,000 meters a second were observed. (*Ann. Chim. Phys.*, March, 1886, VI, VII, 289.)

Schneebeli has determined the absolute value of the friction-coefficient for air by measuring the volumes which passed through a capillary tube of known length and diameter, between the two extremities of which a constant difference of pressure was maintained. The values obtained range from 0.0001690 to 0.0001734, the mean being 0.0001707, closely according with that of Obermayer, which was 0.0001706, when the difference of pressure was variable and 0.0001704 (corrected) when this pressure was maintained constant. (*Arch. de Genève*, 1885, XIV, 339; *J. Phys.*, June, 1886, II, v, 290.)

Tomlinson has studied the viscosity of air by means of the torsional vibrations of a pair of cylinders or a pair of spheres, suspended vertically from and at equal distances from the center of a horizontal, cylindrical bar, the whole oscillating in a sufficiently unconfined space. The bar was supported by a rather fine wire of copper or of silver. The coefficient of viscosity was determined from observations of the logarithmic decrement of amplitude of vibration, produced by the resistance of the air to the oscillating spheres or cylinders, the distance of the cylinders or spheres from the wire being such that the main part of the loss of energy resulting from the friction of the air was due to the pushing of this air. Five sets of experiments were made with this apparatus, giving for the extreme values of the coefficient at 0°, 0.00017201 and 0.00017404, the mean being 0.00017296, with a probable error of only 0.14 per cent. (*Nature*, February, 1886, XXXIII, 403.)

A subsequent experiment was made by Tomlinson at the suggestion of Stokes, in which a hollow paper cylinder about 2 feet in length and 6 inches in diameter was suspended through its axis to a light, hollow, horizontal bar about seven inches long, to the middle of which the wire was soldered. The mean value obtained for the coefficient was 0.00017746 at 12.65°; that previously obtained having been 0.00017711 at 11.79°. In the latter case the loss of energy is due to the dragging of the air. (*Nature*, December, 1886, XXXV, 165.)

Holman has studied the effect of temperature upon the viscosity of air and of carbon dioxide, using for this purpose capillary tubes about 30 centimeters in length. The results of the measurements seem to show conclusively, as the author thinks, that the variation of the viscosity with the temperature of the gas, at least in the case of dry carbonic acid and of dry air freed from carbonic acid, which may be taken as typical gases, is not proportionate either to the square root or to any numerical power of the absolute temperature reckoned from—274°. They point therefore to the inference that all hypotheses yet advanced to account for the variation of the viscosity of gases and hence also for

the viscosity itself are incomplete for this phenomenon. (Proc. Am. Acad., May, 1885; Phil. Mag., March, 1886, V, *xxi*, 199.)

Krawitch has communicated to the Russian Physico-Chemical Society a paper on the relation between the elasticity and density of the air in a rarefied condition. His experiments on the velocity of sound show that at a temperature of 17.5 this velocity decreased from 330 meters at a pressure of 761 millimeters to 171 meters at a pressure of 2.6 millimeters. At a pressure of 280 millimeters the velocity is about the same as at the mean air pressure, but it diminishes rapidly below 280 millimeters. He concludes that below this pressure gases do not obey the law of Boyle-Marriotte. (Science, February, 1886, *vii*, 161.)

Certain irregularities in the experiments made by Bohr on the loosely combined oxygen in oxyhæmoglobin led him to investigate the accuracy with which, under low pressures, this gas follows Boyle's law. The results of this investigation seem to him to prove indisputably that oxygen varies considerably from the law under these conditions. In the course of the experiments the unexpected phenomenon was met with that the curve which expresses the relation between volume and tension exhibits a strongly marked discontinuity at a certain tension, which seems to suggest that there is here an alteration in the molecular composition of oxygen. He finds that at a temperature between 11° and 14° oxygen deviates from Boyle's law within the limits in question. The relation between volume and pressure, when the latter is greater than 0.70 millimeter, being expressed approximately by the formula  $(p+0.109)v=k$ ; while for pressures below this value the formula becomes  $(p+0.070)v=k$ . Moreover, if the pressure sinks below 0.70 millimeter oxygen undergoes a change of state. By raising the pressure above 0.70 millimeter it may be restored to its original condition. (Wied. Ann., 1886, No. 3; Phil. Mag., April, 1886, V, *xxi*, 368.)

A paper on the properties of matter in the gaseous and liquid states under various conditions of temperature and pressure, by the late Thomas Andrews, has been presented to the Royal Society by its president, Professor Stokes. The following are its conclusions: (1) The law of gaseous mixtures, as enunciated by Dalton, is largely deviated from in the case of mixtures of nitrogen and carbonic acid at high pressures, and is probably only strictly true when applied to mixtures of gases in the so called perfect state; (2) the critical point of temperature is lowered by admixture with a permanent gas; (3) when carbonic acid gas and nitrogen diffuse into each other at high pressures the volume of the mixture is increased; (4) in a mixture of liquid carbonic acid and nitrogen at temperatures not greatly below the critical point, the liquid surface loses its curvature and is effaced by the application of pressure alone, while at lower temperatures the nitrogen is absorbed in the ordinary way and the curvature of the liquid surface is preserved so long as any portion of the gas is visible. (Nature, April, 1886, *xxxiii*, 550.)

Winkelmann proposes to show the velocity of diffusion in different

gases by filling air and hydrogen into two equally long barometer tubes so that the mercury is at the same height in each. If, now, ether in excess be added to each tube, the mercury sinks more rapidly in the tube containing hydrogen, and after a few minutes the tubes show a marked difference of pressure, proving the vapor to diffuse far more rapidly in hydrogen than in air. Ultimately, after some hours, the difference of pressure in the two tubes diminishes and becomes zero. (Wied. Ann., 1886, No. 3; Phil. Mag., May, 1886, V, xxi, 451.)

Lommel has described an aerostatic balance, useful for demonstrating the specific gravity of gases in lecture experiments. Under one scale-pan of a balance is hung, by means of a wire, a closed glass balloon which is inclosed in a glass vessel having in its cover a small hole for the wire. This vessel has a side tube near the bottom, provided with a stop-cock. The instrument is balanced, while the vessel is filled with air. If, now, another gas is allowed to stream in and displace the air, the balloon rises or sinks according as the gas is heavier or lighter than air. By adding weights in one scale-pan or the other equilibrium is restored, and it is then easy to find how much, more or less, a volume of gas equal to that of the balloon weighs than the same volume of air at the same temperature and pressure. (Wied. Ann., 1886, No. 1; Nature February, 1886, xxxiii, 397.)

Grunmach has reported to the Berlin Physical Society on his barometric investigations, and has described at length the arrangement of the normal barometer, the vacuum of which was measured in an electrical way. A combination of the barometer vacuum with a Geissler tube permitted the exhaustion to be examined even beyond the limits of the pressures measurable by the cathetometer. The occurrence of the phosphorescent light in the spectrum tube is a standard for the highest degree of rarefaction, in which the vacuum is filled with mercury vapor having a tension of only 0.01 to 0.02<sup>mm</sup>. A still better vacuum would be obtained when the mercury was satisfactorily absorbed, a condition which he had in vain tried to accomplish with selenium. A large number of normal barometers were compared with this, by a method already described at length, using the developed reduction formulas. As a result it appeared that the impurity of the free mercury-cup increased the height of the meniscus and so the recorded height of the barometer. In the subsequent discussion Goldstein proposed for the electrical measurement of the vacuum, instead of a Geissler spectrum tube, the employment of a wide tube which lets the phosphorescence become more evident. But for the determination of the highest degrees of exhaustion he maintained that the thermometer was better adapted than the phosphorescent tube. If a thermometer be placed in a vacuum tube whose positive pole was a point, and whose negative electrode was a steel plate nearly filling the tube opposite the cathode, then the thermometer, when the exhaustion reached the point that light appeared on the cathode, would rise 80° to 90° above the temperature of the room. At



the positive pole the rise was only  $3^{\circ}$ . This rise of temperature in the light from the cathode, he thought, might be utilized to determine the degree of exhaustion. (*Nature*, March, 1886, XXXIII, 480.)

## ACOUSTICS.

Bakmetieff has investigated the sounds which are produced by rods of magnetic metal under the influence of intermittent magnetization. He finds that the intensity of the sound diminishes by longitudinal compression in the case of iron and of nickel rods. As to tension, it diminishes indefinitely the intensity of the sound in nickel, but in iron it causes it to diminish to a minimum only, and then as the tension increases the sound becomes louder again. But, on the other hand, Joule has shown that iron submitted to a certain tension no longer elongates by magnetization; and further that if the tension be still more increased it actually shortens during magnetization. Barrett has shown, too, a diminution of the length of a nickel rod by magnetization. Hence the author concludes that it is the change of the length which is the cause of the sound produced by intermittent magnetization. (*J. Soc. Phys. Chim. Russe*, 1885, XVII, 65; *J. Phys.*, February, 1886, II, v, 91.)

Semmola has observed that if a metallic plate or a sonorous cord be traversed by very frequent discharges from an electric machine, they give a sound which though very feeble is yet entirely distinct from the noise of the spark. To hear this sound it is necessary to fix the metal plate at the end of a sonorous collector of ebonite, which is brought near the ear. The sounds become more acute in proportion as the discharges succeed each other more frequently. Sound is also obtained from a metal plate which is placed near to a conductor which is itself traversed by electric discharges. The plate in this case should be connected to earth, so that it may be said that the sounds which are thus produced by induction are like the phenomena of the return shock. (*C. R.*, May, 1886, CII, 1059.)

Violle and Vautier have studied the propagation of sound in a cylindrical tube 0.70 meter in diameter designed to convey the water of Rochefort to Grenoble. The portion of the conduit utilized consisted of two straight parallel tubes, each 6.375 kilometers in length, which could be used separately or joined at one end by a semicircular tube of the same diameter. The receiving apparatus used was in part that of Regnault, with thinner membranes, and in part the manometric tambours of Marey. The sonorous wave was produced by means of musical instruments or pistol-shots. When a pistol is fired at one end a series of reverberations is heard, and in 18.6 seconds the sound reaches the bend, returning in 37.3 seconds to the end of the second tubes, having traversed 12.75 kilometers. It is distinctly perceptible by the ear as a single, dull sound. Accompanying it is a strong puff of air, which at somewhat greater distances is the only thing perceived. This,



however, is observable even at 50 kilometers distance. Although its energy is superior to that of the greater number of musical sounds perceivable by the ear, yet absolutely nothing is heard. Substituting a recording tambour for the ear, with a chronometric fork for comparison, the air-pressure curves for multiple lengths of the tube were obtained, and from these exact measurements were made. The time required for the wave front to pass once, twice, thrice through twice the length of the tube was measured on the Regnault chronograph with the lever-tambour and with an extremely sensitive membrane having an electric contact. The first passage through the tube required 37.259 seconds by the tambour and 37.251 by the membrane; the second required 37.337 and 37.334, respectively, and the third 37.383 and 37.384 seconds. Hence it would seem that the velocity of propagation diminishes with the intensity. (C. R., January, 1886, CII, 103.)

Neyreneuf has continued his researches upon the velocity of sound in gases and has extended his experiments to vapors. The apparatus used was a modified form of that described in the last report, consisting of a reed and draw tube. The mean of twenty-four accordant determinations in the case of steam gave a wave-length of  $40.63^{\text{cm}}$  with a mean error of 0.18, the value obtained for air in the same apparatus and at the same temperature,  $100^{\circ}$ , being  $28.5^{\text{cm}}$ . In the experiments with alcohol and ether, three reeds were used, the wave-length ratios in air and alcohol being for the three 1.239, 1.219, and 1.217, respectively, while the wave-length in air is to that in ether as 1.71 and 1.706 to 1, respectively. Assuming as the ratio of the specific heat of air at constant pressure to that at constant volume the value 1.41, the author calculates this ratio for steam and for the vapors of alcohol and of ether and obtains the values 1.321 for the vapor of water, 1.14 for that of alcohol, and 1.093 for ether vapor. Ann. Chim. Phys., December, 1886, VI, IX, 535-553.)

Tomlinson has pointed out the fact that Wertheim's statement that the velocity of sound in iron and steel is increased by a rise of temperature not exceeding  $100^{\circ}$ , is erroneous. While it is true that the longitudinal elasticity of iron, as determined by the static method, will be found greater at  $100^{\circ}$  than at  $0^{\circ}$ , provided we begin with the lower temperature first and the wire has not, after the original annealing, been previously raised to  $100^{\circ}$ ; yet this apparent temporary increase of elasticity is a really permanent one; and if the wire be repeatedly heated to  $100^{\circ}$  and afterwards cooled, subsequent tests will always show a less elasticity at the higher temperature than the lower, if sufficient rest after cooling be allowed. When however we come to such molecular displacements as are involved in the passage of sound through a wire, even the apparent increase of elasticity above mentioned vanishes. He had been able to prove that when an iron or a steel wire is thrown into longitudinal vibrations, so as to produce a musical note, the pitch of this note becomes lower as the temperature is raised, even when the

wire is heated for the first time after it has left the maker's hands. (Nature, April, 1886, xxxii, 582.)

Mach has indorsed von Helmholtz's theory of sonorous sensations, and has attempted to render it more complete by supposing that each fiber of Corti vibrates, not only to its predetermined fundamental note, but also, though more feebly, to the harmonics and even the subharmonics of this note. From this arises an auxiliary sensation of timbre and a characteristic perception of musical intervals. (Anz. Ak. Wein, 1885, 275; J. Phys., May, 1886, II, v, 243.)

Robin has discussed the theory of the gamut and has given a table in which are compared the number of vibrations of the notes of the scale, the logarithms of these, and the lengths of strings giving these notes, for the tempered gamut, the gamut played by musicians, and that in use by physicists. An inspection of the table shows: (1) That the tempered gamut, imposed practically upon all instruments with fixed keys, differs much less from the gamut of the musicians than from that of the physicists; and (2) that the differences between the two latter, notable for *mi*, *la*, *si*, and for almost all the altered notes, are especially great for *re*, *sol*, and *la* sharp, reaching nearly a semi-tone. (J. Phys., September, 1886, II, v, 419.)

Boutet has made an experimental study of the best means of producing pure and constant sounds in tubes, and especially of the influence of the material, of the form, of the diameter, and of the thickness of sonorous orifices. The results are given in the form of tables. (Ann. Chim. Phys., November, 1886, VI, ix, 406.)

Von Lang has suggested the use of the Hipp chronoscope for the purpose of determining the pitch of a tuning-fork. To do this the regulating spring of the chronoscope is adjusted to produce a note very near in pitch that of the fork. By suitably bowing it, the fork is kept in vibration for several minutes, and the beats produced by the two sounds during this interval are counted. The chronoscope itself records the number of vibrations of its spring; so that by adding to this the number of the beats during the same time, the number of vibrations of the fork may be determined to within about one-twenty-fifth of one vibration. (Anz. Ak. Wein, 1885, 221; J. Phys., May, 1886, II, v, 340.)

Doumer has proposed to use manometric flames for the purpose of measuring pitch. In principle the method is simple. Two manometric flames are employed, placed near each other, one vibrating under the influence of a sound whose pitch is exactly known, the other under that of the sound to be measured. On measuring in the revolving mirror how many vibrations of the latter correspond to a definite number of the former, a simple proportion gives the pitch. In practice, however, it is not easy to obtain in this way exact results. The author has therefore made use of a moving sensitive plate and has photographed simultaneously the images of the two flames. These flames were of gas treated with benzine and burnt in oxygen. A lens of short focus pro-

duced their images on the plate, which was moved by a special mechanism. (C. R., August, 1886, CIII, 340.)

Fossati has suggested the use of the microphone, in order to determine the position of the nodes and loops in a sounding air column. The microphone is connected in the circuit of a telephone and one or two cells of battery, and is lowered into the vibrating tube. At the nodes it is thrown into vibration and the telephone sounds strongly. If the telephone is omitted and the battery increased to five or six Bunsen cells, then on using a glass tube and lowering the microphone into it in the dark, bright sparks are observed at the nodes where it is thrown into vibration, while at the loops it remains dark. This form is striking as a lecture experiment. (Il Nuovo Cimento XVII, 261; J. Phys., December, 1886, II, v, 569.)

Thompson has expressed the opinion that the fact that the frequency of vibration of an electrically-maintained fork is continually changing, is in consequence of giving the impulses to the prongs at a disadvantageous moment, namely, when they are at the extremities of their swings. It is desirable, therefore, that the impulse should be given at the middle of the swing, and to effect this he has suggested that each fork should make and break the circuit of the magnet influencing the other one, and he has shown how the electrical connections can be made to effect this in a simple manner. (Nature, July, 1886, xxxiv, 283; Phil. Mag., August, 1886, V, xxii, 216.)

C. A. Bell has presented a paper to the Royal Society upon the sympathetic vibration of jets, giving the results of extended experiments upon both gaseous and liquid jets, their vibrations being studied by placing some portion in circuit with a battery and telephone, thus rendering these vibrations audible. (Science, June, 1886, vii, 494.)

Wead has experimented to determine the actual time of contact between the hammer and the string in a piano. The method was simple. An electric circuit was completed through a cell, a resistance box, a galvanometer, a fine wire round the stem of the hammer, a slip of thin gold foil glued to the face of the hammer, the piano string, and the frame. The contact between the hammer and string produces a momentary closing of the circuit and a throw of the galvanometer needle, from the amount of which the time of closing may be calculated. The observations upon C, which made thirty-four double vibrations per second, were very satisfactory and showed that the contact time for a very soft stroke is about 20 per cent. greater than for an ordinary or hard blow. The conclusion reached is that for an ordinary blow the time of contact is one-sixth of the vibration period of the string instead of three-fourteenths as was estimated by von Helmholtz. (Am. J. Sci., November, 1886, III, xxxii, 366.)

Violle has described to the French Academy an apparatus for showing the two modes in which a vibratory motion is reflected according as the end of the tube is open to the atmosphere or is closed by a solid



partition. In the latter case the velocity changes sign and the condensation does not; in the former the opposite is the fact. (C. R., December, 1886, c III, 1255.)

## HEAT.

1. *Production of heat.—Thermometry.*

The values of the solar constant which have been given by Pouillet, Hagen, Crova, Violle, and Langley have been examined by Maurer. In his opinion the considerably higher values of Violle and Langley arise from the assigning by these experimenters of too high a value for the amount of solar radiation on the earth's surface. Actimometric measurements have recently been made with a new apparatus of Weber's, under remarkably good atmospheric conditions. Six of these were made on the terrace of the Polytechnicum at Zurich, two on the top of the St. Gothard Pass (2,100 meters), and one on the Pizzo Centrale (3,000 meters). According to these, the maximum heat from the sun at mid-day which a surface of one square centimeter receives in a minute under perpendicular radiation is, in Zurich, from 1.10 to 1.32 thermal unit; on the St. Gothard 1.38 to 1.41 unit; and on the Pizzo Centrale, 1.52 unit. (Beibl. Phys., X, 82; Phil. Mag., Sept., 1886, V, xxii, 312.)

Keller has sought to measure the increase of temperature produced by a water-fall. In his experiments at Terni he obtained measurements varying between  $0.08^{\circ}$  and  $0.73^{\circ}$ , while the calculated value was  $0.37^{\circ}$ . Hence, while these results seem to prove the transformation of kinetic energy into heat under these conditions, it is evident that they are powerfully affected by the sources of error which he discussed. (Beibl. Phys., x, 333; Phil. Mag., Sept., 1886, V, xxii, 312.)

The use of gas for heating and motor purposes has rendered the determination of its heating power of great interest. Witz has made careful experiments in this direction, using a nickel-plated steel explosion cylinder 2.36 inches in internal diameter and 3.54 inches high, the metal being 0.079 inch thick. The top and bottom covers were screwed on air-tight. Through the top cover a wire passed, and in the bottom was a valve for filling or emptying the cylinder. In use it was placed in a vessel 4 inches in diameter and 8 inches high, which acted as a calorimeter, and held about 1.76 pints of water. The mixture of air and gas was placed in the cylinder over mercury and fired by an electric current. As the result of a large number of experiments it appears that the gas used in the experiments gives in burning about 5,200 calories (kilogram-degrees centigrade) per cubic meter, equivalent to 584 pound-degrees Fahrenheit per cubic foot. This accords fairly with the values obtained by Dugald Clerk, which are 489,268 and 504,888 foot-pounds per cubic foot as the mechanical value of London and Manchester gas, corresponding to 5,372 and 5,640 calories. The heating power of gas may be increased 77 percent. by carburization. (Ann. Chim. Phys., 1885, VI, vi, 256; Science, May, 1886, vii, 467.)



Boltzmann has established theoretically the possibility of basing the kinetic theory of gases upon the assumption of attractive forces only, but under the express condition that these forces cease to act at infinitely small distances. (*Wied. Ann.*, xxiv, 37; *J. Phys.*, Nov., 1886, II, v, 504.)

Potier has discussed the law of freezing mixtures with reference to the principle of maximum work, and shows that a direct combination with absorption of heat is possible only when the temperature is superior to that of dissociation; while at a temperature inferior to that at which dissociation commences, only combinations which evolve heat can be formed. The inequality of Clausius establishes thus a connection between the principle of maximum work of Berthelot and the fact that a high temperature is more often required to begin the dissociation; and this without giving by itself alone the explanation either of the principle of maximum work or of the effect of a high temperature. (*J. Phys.*, Feb., 1886, II, v, 53.)

Pictet, in his memoirs upon freezing-machines, has called attention to the remarkable properties, for purposes of refrigeration, of a mixture of liquefied carbon dioxide and sulphurous oxide gases, obtained by compressing the product obtained by the action of sulphuric acid on charcoal. The mixed liquid has this peculiarity, that its vapor pressure increases less rapidly with the temperature than that of sulphurous oxide alone; so that it reaches this pressure between 25° and 30°, and becomes less beyond it. The vapor pressure of the mixed liquid is not only much less than that of carbon dioxide, but actually less at temperatures above 25° than that of sulphurous oxide. The author thinks that the two liquids form a compound at high temperature which breaks up at low ones. Since this liquid not only kills microbes, but extinguishes fires, it is also useful for many other purposes. (*Arch. Sci. Gen.*, xix, 570; *J. Phys.*, June, 1886, II, v, 289.)

Lightfoot has presented a paper on ice-making machinery and appliances to the Institution of Mechanical Engineers. He had designed machinery for producing cold by the expansion of air after compression, in which a weight of 1,000 pounds of air per hour can be reduced from 60° above to 80° below the Fahrenheit zero, the cooling water being at 60° F., with the expenditure of about 18 indicated horse-powers. A novel application of freezing-machines was made in Stockholm in excavating a tunnel through gravel which was mixed with clay and water. The innermost end of the tunnel was made into a freezing chamber, and the gravel, etc., frozen; then it was easily removed. In this way it was driven successfully for a distance of 80 feet. (*Nature*, May, 1886, xxxiv, 45.)

Horace Darwin has described an improved form of temperature regulator, constructed for use in the room at the Standard's office, where the comparisons are made. Its action depends on the variation of pressure of a saturated vapor caused by a change of temperature. The liquid

used as a mixture of methyl and ethyl chlorides boiling at about  $2.5^{\circ}$  under normal atmospheric pressure. The greatest daily change of temperature observed in the room during a fourteen-day test was  $.04^{\circ}$ , and the least  $.01^{\circ}$ . The details of construction and of management are given in the paper referred to. (Nature, April, 1887, XXXIII, 596. See also Pernet, Nature, May, 1886, XXXIII, 48.)

On thermometric questions Whipple has described the method in use at the Kew Observatory for the comparison and verification of thermometers at the freezing point of mercury. (Phil. Mag. January, 1886, V, XXI, 27.) Pickering has published notes on the calibration and standardizing of mercurial thermometers, and has described a modification of his own, in delicate thermometers for calorimetical work. (Phil. Mag., March, April, 1886, V, XXI, 180, 330.)

## 2. Expansion and change of state.

Weber has proposed the use of the pendulum method for determining the co-efficient of expansion of solids. The time of oscillation of a solid body *in vacuo* depends on the form of the body, on its mass, and on the distance of its particles from the axis of rotation. At two different temperatures these distances are different, and hence the times of oscillation differ. In other words, there is for every body a definite relation between its temperature  $u$ , its expansion co-efficient  $a$ , its dimensions  $d$ , and its time of oscillation  $t$ , which is expressed by the formula

$$a = \frac{t^2 - t'^2}{u t'^2 - u' t^2}.$$
 The time of oscillation is to be obtained by noting

exactly the interval between two passages of the pendulum through the vertical, six hours apart, using for this purpose a Hipp chronoscope whose hands are put in motion by the pendulum of an accurate clock and stopped by the pendulum under experiment. The temperature is determined by means of a thermo-electrical couple. In this way the author hopes for a precision of one hundred-thousandth part in the co-efficient, in place of one six-thousandth with the present methods. (C. R., September, 1886, CIII, 553.) In a subsequent note Guillaume criticises this method, and shows that with the best possible installation a precision of not over one three-hundredth part is to be expected by its use; and, moreover, the apparatus is complicated. (C. R., October, 1886, CIII, 689.)

A simple apparatus for showing that a wire is cooled when it is stretched has been described by Dorn. A steel vertical wire, about  $0.7^{\text{mm}}$  in diameter, is clamped at the upper end, while at the lower is fixed a scale-pan in which weights can be placed. Round two adjacent portions of this wire pieces of fine German-silver wire and of steel wire are wound, the ends of which are so connected with a galvanometer that they form a thermo-element. When weights are placed in the pan the galvanometer shows a cooling effect, and when, after a time, they are removed, a warming effect. With a Wiedemann's galvanometer, almost dead-beat,

arranged for projection with lamp, lens, and scale, a deflection of several centimeters was obtained. The contact points of the dissimilar metals must, of course, be protected from air currents. This may be done with felt. (*Wied. Ann.*, 1885, xxvi, 334; *Phil. Mag.*, January, 1886, V, xxi, 80.)

Grimaldi has studied the expansion of ethyl oxide at pressures varying from 1 to 25 meters of mercury and at temperatures from  $0^{\circ}$  to  $105^{\circ}$ . He finds that the equation of Avenarius, representing the expansion of liquids at the critical pressure, is true approximately for the expansion of ether at various pressures up to this point, provided that at each pressure the different co-efficients are employed. The formula then gives values differing by only about 1 per cent. from the experimental results. (*J. Phys.*, January, 1886, II, v. 29.)

In consequence of Whipple's communication to the Physical Society of London on testing thermometers down to the melting point of mercury, the question was raised as to the uniformity with which this metal contracted between  $0^{\circ}$  and  $-39^{\circ}$ . Ayrton and Perry have tested this matter experimentally, comparing the readings of a mercurial thermometer loaned them by Whipple with those of a constant-volume air thermometer, both immersed in a bath of frozen mercury which was allowed gradually to become warm. When the results were plotted, they formed a straight line so nearly that the conclusion may be drawn that mercury expands as regularly below  $0^{\circ}$  as above  $0^{\circ}$ , and that there is no critical point for this substance above its freezing point, as there is for water. Hence temperatures down to  $-39^{\circ}$  may be correctly measured by a mercury thermometer the stem of which is graduated for equal volumes. (*Nature*, April, 1886, xxxiii, 575; *Phil. Mag.*, October, 1886, V, xxii, 325.)

Roth has proposed to determine fusing points by placing the substance in a tube of glass and immersing it in sulphuric acid, which is then gradually heated. The apparent temperature of fusion is noted on a thermometer placed in the acid, and a small empirical correction gives the true temperature of fusion. (*Ber. Berl. Chem. Ges.*, July, 1886, xix, 1970.)

Raoult has investigated the effect of mixing salts in solution upon the temperature at which these solutions congeal. Calling the quotient obtained by dividing the actual lowering of the freezing point by the weight of the anhydrous substance dissolved in 100 grams of water the co-efficient of depression, he enunciates the following law: If several substances, without chemical action on each other, are simultaneously dissolved in 100 grams of water, each substance lowers the freezing point in the ratio of its weight and of the co-efficient of depression which it possesses at the temperature of freezing of the mixture. Again, calling the depression which would be produced by a molecule of any substance in 100 grams of water the molecular depression, the author gives the following rule for obtaining its value: Trace the curve of the co-



efficient of depression of the body supposed anhydrous from  $1^{\circ}$  to  $4^{\circ}$ ; prolong the sensibly rectilinear part of this curve until it meets the axis of ordinates; multiply the ordinate of the point of intersection by the molecular weight of the substance dissolved, supposed anhydrous; the product obtained will represent exactly the molecular depression sought. (J. Phys., February, 1886, II, v, 64.)

Von Helmholtz has communicated to the Physical Society of Berlin the method by which he determined the minimum diminution of vapor pressure necessary to produce condensation of vapor, the heat being constant. A glass cylinder was one-third filled with the liquid to be tested. Its upper portion, containing the mixture of air and vapor, was connected on one side with a manometer, and on the other with a tap through which the exhaustion could be effected. The formation of cloud was detected by directing a beam of light through the axis of the cylinder, and by looking along a line making a small angle with this axis, the eye being screened from the direct light. At ordinary temperatures a depression of  $10^{\text{mm}}$  of water was required to produce the cloud, while at  $0^{\circ}$  a depression of  $12^{\text{mm}}$  was required. The statements of Coulier and Aitken were confirmed, that the formation of cloud in saturated air was induced solely by particles of dust. Saturated air, completely free of dust, might suffer a depression of half an atmosphere without formation of any cloud without it. (Nature, April, 1886, XXXIII, 552.)

Ramsay and Young have used an improved apparatus to determine the vapor pressure of mercury. It consisted of a U tube inclosed in a jacket containing the substance whose boiling point gave the temperature and connected with a manometer. The U tube was first filled with mercury and boiled to expel air. Then on heating it and diminishing the pressure by means of a pump, vapor was evolved from the mercury, which depressed the level on one side and raised it on the other. From the difference of level in this tube and in a manometer gauge connected with it, the vapor pressure was calculated. At  $222.15^{\circ}$  the vapor pressure of mercury was found to be  $34.4^{\text{mm}}$ ; at  $270.35^{\circ}$  it was  $124.35^{\text{mm}}$ ; at  $280.60^{\circ}$ ,  $157.15^{\text{mm}}$ ;  $358.47^{\circ}$ ,  $767.43^{\text{mm}}$ , and at  $448^{\circ}$ ,  $2904.5^{\text{mm}}$ . (J. Chem. Soc., January, 1886, XLIX, 37.)

Vincent and Chappuis have determined in Cailletet's apparatus the critical temperature and pressure for two series of gaseous substances, the members of each of which series differed in composition by  $\text{CH}_2$  and showed a gradation of similar chemical properties. The first series contained hydrogen chloride, methyl chloride, and ethyl chloride; the second ammonia, methylamine, dimethylamine, and trimethylamine. For hydrogen chloride the critical temperature was  $57.5^{\circ}$  and pressure 96 atmospheres; for methyl chloride  $141.5^{\circ}$  and 73 atmospheres; for ethyl chloride  $54^{\circ}$  and 182.5 atmospheres. For ammonia the values were for critical temperature  $131^{\circ}$  and pressure 113 atmospheres; for methylamine  $155^{\circ}$  and 72 atmospheres; for dimethylamine  $163^{\circ}$  and 56 atmospheres, and for trimethylamine  $160.5^{\circ}$  and 41 atmospheres. Hydrogen chloride



and ammonia seem to follow Dewar's law, that the ratio between the absolute critical temperature and the pressure is constant. The other substances deviate from it, giving ratios which increase with molecular complexity. (J. Phys., February, 1886, II, v, 58.)

Subsequently these authors extended their observations to include propyl chloride, the three ethylamines, and the two lower normal propylamines, all liquid at the ordinary temperature. Their results confirmed those above mentioned, that the absolute critical temperature increased with molecular complexity somewhat more rapidly than the critical pressure. Moreover the critical temperatures and pressures of isomeric substances are far from being equal. (C. R., August, 1886, CIII, 379.)

In a lecture at the Royal Institution, Frederick Siemens discussed the phenomena of dissociation with especial reference to questions connected with practical heat operation. (Nature, May, 1886, XXXIV, 64.)

Wroblewski has determined the density of liquified atmospheric air as well as that of its component gases, by measuring the volume of gas given by a known volume of the liquid. At the critical temperature— $118^{\circ}$ , the density of liquid oxygen is 0.6; while at  $-200^{\circ}$ , at a pressure of only 2 centimeters, the density is 1.24. Hence its atomic volume is less than 14. The density of liquid nitrogen at  $-146.6^{\circ}$ , the pressure of its saturated vapor being 32 atmospheres, was found to be 0.4552; while at  $-793^{\circ}$ , under a pressure of one atmosphere, the density was 0.83; and at  $-202^{\circ}$ , with a pressure of 0.105 atmospheres it was 0.866. The atomic volume is then about 15.5. Its expansion coefficient is 0.0311 at  $-153.7^{\circ}$ , 0.007536 at  $-193^{\circ}$ , and 0.004619 at  $-202^{\circ}$ . Atmospheric air on compression behaves like a mixture whose components followed different laws of liquefaction; and when liquified its composition changes with change of temperature or pressure. The value of the density found by experiment at  $-146.6^{\circ}$  and under a pressure of 45 atmospheres was 0.59. Calculation gives 0.60 as the value obtained from liquid oxygen and nitrogen. (C. R., May, 1886, CII, 1010.)

Nilson and Peterssen have described a new method for determining the vapor density of volatile substances and at the same time the temperature of the experiment. Four determinations with this apparatus, of the density of the vapor of glucinum chloride at temperatures varying from  $1080^{\circ}$  to  $1502^{\circ}$ , gave 2.77 as the mean value. (Ann. Chim. Phys., December, 1886, VI, ix, 554.)

Nodon has utilized the hygroscopic properties of gelatine in the construction of a recording hygrometer. A layer of this substance is fastened to the outside of a helix of Bristol board, the inside being protected by a non-hygroscopic varnish. An increase in the atmospheric moisture expands the gelatine and unrolls the helix, as a change of temperature does the helix of Breguet's thermometer. The result appears within ordinary limits to be independent of temperature. The hygrometer consists of four such helices grouped in pairs upon the same

frame. One of the ends of each helix is fixed; the other acts on a pulley so arranged that their mechanical actions are added. The two pullies carry a silk thread attached to a light slide, moving between vertical guides, and carrying a style which presses against a cylinder carrying the paper and moved by clock-work. The hygrometric curve is thus inscribed on the paper. (J. Phys., October, 1886, II, v, 461; C. R., June, 1886, CII, 1371.)

Luvini has published a series of experiments made by him on the spheroidal state with distilled water, soap-water, alcohol, and ether. He has made the interesting observation that in rarefied air the temperature of the spheroidal mass diminishes. On lowering the pressure from 420<sup>mm</sup> to 50<sup>mm</sup>, the liquid, always in the spheroidal condition and near an incandescent wall, falls in temperature from about 83° to near 40°; that is, to a temperature at which the maximum elastic force of the vapor is equal to the external pressure. In a closed vessel the temperature of the spheroidal liquid rises above the normal temperature of ebullition. It is common in blowing glass to inject a little water into the cavity formed in the hot glass. The liquid becomes spheroidal and its vapor blows out the glass. (Il Nuovo Cimento, 1885, XVII, 15; J. Phys., December, 1886, II, v, 569.)

### 3. Conduction and radiation.—*Specific heat.*

Graetz has given the results of his determinations of the conductivity of liquids for heat, made by his new method, which consists in causing the liquid to flow at a given temperature through a narrow metallic tube whose exterior is maintained at a somewhat lower temperature, and in determining the mean temperature and the volume of the liquid which has passed during a given time, when the stationary condition has been established. Assuming that the flow of liquids in narrow tubes may be calculated from Poiseuille's law, the determination of the coefficient of interval conductivity depends on the solution of an equation of partial differences of the second order, which contains no other constants to be determined by experiment than the mean velocity of flow and the radius of the tube. The values obtained were for glycerine 0.0382, alcohol 0.0327, ether 0.0227, petroleum 0.0213, turpentine 0.0195, and carbon disulphide 0.0160. The quotient of this coefficient by the product of the density and the specific heat is nearly constant. This coefficient increases slightly with the temperature. (Wied. Ann., XXV, 337; J. Phys., November, 1886, II, v, 506.)

The law according to which an incandescent body emits energy has been studied by Möller. A sheet of platinum carried to incandescence by a current, is inclined at an adjustable angle before a Wild photometer, a similar plate of platinum unaltered in position being used for comparison. Wild's photometer consists of a double prism which brings the beams from the two sources into a common direction, the base of which is covered with ground glass. The emergent and juxtaposed

beams traverse a nicol, then a rhombohedron of spar cut of such a thickness that the ordinary ray from one of the sources of light and the extraordinary ray from the other issue juxtaposed. The two beams are received by a telescope, having previously been equalized in intensity by rotating the nicol. From this rotation the original intensities are calculated. The results of measurements thus made confirmed very closely the law of the cosines, and also showed that the amount of emitted energy polarized perpendicular to the plane of incidence increases rapidly with the obliquity. (Wied. Ann., XXIV, 266; J. Phys., November, 1886, II, v, 574.)

Mercadier has divided radiophones into two classes: (1) those in which the transformation of radiant energy into mechanical energy in the form of sound is produced directly, and (2) those in which this transformation of energy is effected indirectly through one or more intermediate stages. The original photophone of Bell, in which the intermittent beam fell on selenium, and thus affected an electric circuit in which a telephone was placed, was of the latter class. The author has observed that if a beam of intermittent radiations be allowed to fall upon the diaphragm of a microphone, the corresponding note is distinctly heard in a telephone in circuit with it; and further, such a beam is capable of producing the same effect when thrown on the diaphragm of a magneto transmitting telephone. (J. Phys., May, 1886; II, v, 215.)

Langley has continued his researches on radiant energy and has now published his observations on invisible heat spectra and the recognition of hitherto unmeasured wave lengths. As radiating surfaces Leslie cubes were employed, covered with lampblack and filled with boiling water giving  $100^{\circ}$ , or aniline giving  $178^{\circ}$ . In some cases the cubes were filled with ice, and even with freezing mixtures, at a temperature of  $-20^{\circ}$ . The apparatus consisted of a rock salt train, made up of two rock salt lenses  $75^{\text{mm}}$  diameter and  $350^{\text{mm}}$  focus, and a rock salt prism  $64^{\text{mm}}$  on a side. The conclusions reached from an examination of the curves are (1), that the heat now measured is almost altogether of a character not observed in that of the sun, the wave lengths not being transmissible by glass; (2) that notwithstanding the compression of the infra-red by the prism, these heat curves extend almost indefinitely in that direction, the Leslie cube, for instance, at  $178^{\circ}$ , showing very measurable heat at a deviation of  $33^{\circ}$ , corresponding to a refractive index of 1.4511; (3) that an increase of temperature increases every ordinate, but not equally, those in the more refrangible portions growing most rapidly; (4) that hence there is a progressive movement of the maximum ordinate toward the more refrangible end as the temperature rises; and (5) that these prismatic curves are not symmetrical, the greater portion of the area in every case lying toward the greater wave length. In one of the plates accompanying the paper the curves of two heat spectra are given, one from a surface at the temperature of boiling water, the other at that of melting ice. As first approximations, the author believes that "the



minimum wave length assignable to the minimum ordinate of the heat curve in the spectrum of a source whose temperature varies from  $100^{\circ}$  to  $0^{\circ}$  Centigrade, is a little less than  $5\mu$  and a little over  $6\mu$ ." In other words, that "some of the heat radiated by the soil has probably a wave length of *over* 150,000 of Augström's scale, or about twenty times the wave length of the lowest visible line in the solar spectrum as known to Fraunhofer." This research, therefore, has rendered probable the existence of measurable wave lengths of something greater than one two-thousandths of an inch and has proved that the heat radiated from the soil is of an almost totally different quality from that which is received from the sun. (Am. J. Sci., Jan., 1886, III, xxxi, 1; Phil. Mag., May, 1886, V, xxi, 394; Ann. Chim. Phys., December, 1886, VI, ix, 433.)

In a subsequent paper on hitherto unrecognized wave lengths Langley gives an extended description of the method employed by him for measuring these wave lengths, together with an account of the apparatus used in the research. "Broadly speaking," he says, "we have learned through the present measures with certainty of wave lengths greater than  $0.005^{\text{mm}}$ , and have grounds for estimating that we have recognized radiations whose wave length exceeds  $0.03^{\text{mm}}$ , so that while we have directly measured to nearly eight times the wave length known to Newton, we have probable indications of wave lengths far greater, and the gulf between the shortest vibration of sound and the longest known vibration of the æther, is now in some measure bridged over." (Am. J. Sci., August, 1886, III, xxxii, 83.)

Wiedemann and Leudecking have studied the heat changes which accompany the hydration and solution of colloids. When water is progressively added to colloids such as gelatine, gum arabic, gum tragacanth, dextrine, starch, etc., two stages of the action are observed. In the first these colloids become hydrated with an evolution of heat. In the second the hydrates formed dissolve in the excess of water with absorption of heat. (Wied. Ann., xxv, 145; J. Phys., Nov., 1886, II, v, 495.)

Pickering has pointed out some of the sources of error incident to calorimetical work. He finds that the presence of anything but air between the calorimeter and the jacket is most injurious; the space should be entirely open and no cover of any sort should be used. Before reading the thermometers the top of the stem should be tapped for some time, otherwise the mercury lags behind the true temperature. Moreover a thermometer when rising is invariably too low, and when falling is invariably too high. The error thence arising is avoided by conducting the entire experiment either with a rising or with a falling thermometer. In his experiments the thermometers used had a range of  $15^{\circ}$  and a total length of  $600^{\text{mm}}$ . The readings were made at temperatures between  $-1^{\circ}$  and  $26^{\circ}$ , by the following method: The thermometer was first heated to the highest temperature required in the experiment, and, by the application of a flame to the mercury column



just below the enlarged space at the end of the tube, that part of the mercury above the flame was broken off and driven into the space, where it remained as the thermometer cooled. In this way the same part of the scale could be used for different readings. The relative value of a scale division was affected inappreciably while the absolute value could be obtained by a single comparison with a standard. Further improvements in calorimetry the author thinks lie in improved methods. (*Nature*, Feb., 1886, XXXIII, 405; *Phil. Mag.*, April, 1886, V, XXI, 324.)

The ice melted in the calorimeter of Bunsen is estimated in one of two ways: Either by reading, on a graduated scale attached to the capillary tube in which the extremity of the mercury column moves, the amount of displacement; or by weighing the mercury drawn into the apparatus during the melting. For this purpose a tube twice recurved and drawn out like that of a weight thermometer, to a fine point, dips into a vessel of mercury, and is weighed before and after the experiment. Blumcke has proposed to combine the two methods and to use the divided scale to determine the changes in the calorimeter before and after the experiment, while the weighing method is reserved for the experiment itself. Taps placed at the terminations of the bent tube and the capillary tube permit communication to be established at the proper time between either of these tubes and the calorimeter. (*Weid. Ann.*, XXVI, 159; *J. Phys.*, November, 1886, II, v, 494.)

## LIGHT.

### 1. *Production and Velocity.*

Auer has invented a lamp in which a cylinder of porous magnesia is hung in a Bunsen flame. The burner of the lamp is surrounded by an ordinary cylindrical chimney, and in the flame is hung a hollow cylinder of thin organtine impregnated with the magnesia solution. The heat of the flame destroys the organic matter and leaves the white magnesium oxide in the form of an elastic porous cylinder, which becomes highly incandescent. The lamp is said to give a light of twenty candles with a consumption per hour of 56 liters of gas. (*Science*, March, 1886, VII, 282.)

Chase has called attention to the fact that Herschel's high estimate of the elasticity, or as he called it the "bursting power," of the æther, is not that of the simple ætherial elasticity itself, as has been assumed by Wood and others, but is that which is represented by the ratio of the elasticity to the density; *i. e.*, is that which would be exerted if the air and the æther were reduced to the same density. If we substitute in Herschel's proportion, the true density-ratio, we obtain 1,636,750 as the ratio of the elasticity of air to that of the æther. This represents an ætherial elasticity or "bursting power" of about  $\frac{1}{6820}$  ounce on each side of a cubic inch instead of "upwards of seventeen billions of pounds".

The weight of the cubic inch of æther would be only  $\frac{1}{2,467,500,000,000,000,000}$  ounce. (Phil. Mag., September, 1886, V, XXII, 255.)

J. W. Gibbs has given a résumé of the results obtained by Newcomb (see Nature, May, June, 1886, XXXIV, 29, 170) and by Michelson in their experiments on the velocity of light. As the final result of his Washington experiments Newcomb gives  $299,860 \pm 30$  kilometers per second as the velocity of light *in vacuo*. Michelson's Cleveland experiments give  $299,853 \pm 60$ ; a result substantially identical. Combining the first of these values with Nyrén's value of the aberration constant ( $20.492''$ ), the value 149.60 is obtained as the sun's distance in millions of kilometers. Although both the above experimentors paid especial attention to the question whether there was any difference between the velocity of red and of blue light, not the least indication of any difference was observed. A difference of one-thousandth in these velocities would have given a well-marked color to the return image of the slit in Newcomb's experiments. But no such effect could be detected. Michelson covered one-half the slit with a red glass; the two halves of the return image were exactly in line. Gibbs also gives the values which have been most recently obtained of the ratio between the electro-magnetic and electro-static units, which, according to Maxwell's electro-magnetic theory of light, represents the velocity of this agent. These values, as corrected for the true value of the ohm, are as follows: Ayrtton and Perry, 1878, 296.1; Hockin, 1879, 296.9; Shida, 1880, 295.6; Exner, 1882, 291.7 (?); J. J. Thomson, 1883, 296.3; Klemencie, 1884, 301.88 (?). They should be compared with the velocity of light in air, expressed in millions of meters per second—299.778 according to Newcomb. Setting aside Exner's and Klemencie's values, the other four are closely accordant, their mean being nearly identical with that of J. J. Thomson, which appears to be by far the most worthy of confidence, and differing by only one per cent. from the velocity of light. Michelson's experiments on the velocity of light in carbon disulphide afford, the reviewer thinks, an interesting illustration of the difference between the velocity of waves and the velocity of groups of waves—a subject to which Rayleigh has called attention in an appendix to the second volume of his "Theory of Sound." The quotient of the velocity *in vacuo* divided by the wave velocity in carbon disulphide, calculated from Verdet, is for the line D 1.624 and for E 1.637; while the group velocity, when used as a divisor, gives 1.722 and 1.767, respectively. Michelson's experimental result was  $1.76 \pm .02$ , agreeing well with the latter. (Am. J. Sci., January, 1886, III, XXXI, 62.) Subsequently Shuster has argued in support of Rayleigh's conclusion that the velocity measured by the revolving-mirror method of Foucault is really neither the wave velocity  $V$  nor the group velocity  $U$ , but is  $\frac{V^2}{U}$ . But he shows that if only one revolving mirror be used, the experiment can not be performed in the way mentioned. Hence the Foucault method really measures neither  $V$  nor  $U$ , nor yet

$\frac{V^2}{U}$ , but  $\frac{V^2}{2V-U}$ ; the calculated value of which is 1.758, practically identical with 1.76, the value obtained by Michelson. If a second rotating mirror be used, Rayleigh's value  $\frac{V^2}{U}$  remains true. He concludes, then, that while the aberration method measures  $V$ , and the eclipse of Jupiter's satellites and Fizeau's method measure  $U$ , Foucault's revolving-mirror method measures either  $\frac{V^2}{U}$  or  $\frac{V^2}{2V-U}$ . (Nature, March, 1886, xxxiii, 439.) In reply to this note Gibbs calls attention to the fact that it follows from Rayleigh's formulas that while the individual wave rotates, in the revolving-mirror experiment, the wave-normal of the group remains unchanged; or, in other words, that if we fix our attention on a point moving with the group, and therefore with the velocity  $U$ , the successive wave planes, as they pass through that point, have all the same orientation. "To get a picture of the phenomenon," he says, "we may imagine that we are able to see a few inches of the top of a moving carriage-wheel. The individual spokes rotate, while the groups maintain a vertical direction." This consideration, he thinks, greatly simplifies the theory of Foucault's experiment, and makes it evident that the results of all such experiments depend upon the value of  $U$  and not upon that of  $V$ . (Nature, April, 1886, xxxiii, 582.)

Gony has repeated, by means of Foucault's method, experiments to determine the relative velocity of red and blue rays in carbon disulphide. Several concordant series of observations show the deviation to be greater for blue than for red light, the difference being about 5'', or one twentieth of the deviation for the red ray. This result he thinks is in accord with theory. (C. R., July, 1886, ciii, 244.)

Michelson and Morley have repeated Fizeau's experiment on the influence of the motion of the medium upon the velocity of light. He had announced the remarkable result that the increment of velocity which the light experienced was not equal to the velocity of the medium, but was a fraction of this velocity, which depended on the index of refraction of the medium. The formula of Fresnel is equivalent to the statement that the æther within a moving body remains stationary, with the exception of the portions which are condensed around the particles. If this condensed atmosphere be insisted on, every particle, together with its atmosphere, may be regarded as a single body, and then the statement is simply that the æther is entirely unaffected by the motion of the matter which it permeates. The authors used essentially the same form of apparatus as Fizeau. Light from a given source falls on a half-silvered surface where it divides, one-half being reflected through one of two tubes 28<sup>mm</sup> in diameter and 6 meters long and back through the second, the other half passing through the second tube directly and being reflected back through the first. The tubes being filled with distilled water, the light from an electric lamp was directed



toward the central glass of the refractometer, and the latter adjusted by screws till the light passed centrally down both tubes and then the right-angled prism at the farther end adjusted till the light returned and was reflected into the telescope, where generally two images were observed. These were made to coincide and the fringes at once appeared. At a given signal the current of water was turned on, moving in opposite directions in the two tubes. The width of the central fringe was measured micrometrically and the displacement in one direction. The current of water was then reversed and the displacement again measured. This displacement was nearly the width of an entire fringe. The velocity of the water being determined, the value sought is easily calculated. The authors announce as the result of their work that the conclusion obtained by Fizeau is essentially correct, and that the luminiferous æther is entirely unaffected by the motion of the matter which it permeates. (*Am. J. Sci.*, May, 1886, III, xxxi, 377.) At the next meeting of the French Academy Cornu thus spoke of the foregoing research: "Leur travail conçu dans l'esprit le plus élevé, exécuté avec ces puissants moyens d'action que les savants des États-Unis aiment à déployer dans les grandes questions scientifiques, fait le plus grand honneur à leurs auteurs." Fizeau himself also added his commendations (*C. R.*, May, 1886, cii, 1207).

The British Association committee on standards of white light have made a preliminary report. An examination of existing standards, they say, convinces them that the standard candle as defined by act of Parliament is not in any sense of the word a standard. The French "bec Carcel" is also liable to variations; and with regard to the molten platinum standard of Viollé, it seems that the difficulty of applying it is so great as to render its general adoption almost impossible. As to proposed standards, the majority are satisfied that for all the present commercial requirements the pentane standard of Vernon Harcourt, which has no wick and consumes a material of definite chemical composition, is, when properly defined, an accurate and convenient standard, and gives a much more accurate illumination than the standard candle. As to future researches, the electrical direction seems promising, and a standard of white light might be established defined somewhat as follows: A unit of light is obtained from a straight carbon filament, in the direction at right angles to the middle of the filament, when the resistance of the filament is one-half of its resistance at  $0^{\circ}$  C., and when it consumes  $10^9$  C. G. S. units of electrical energy per second. (*Nature*, January, 1886, xxxiii, 236.)

Koenig has described Weber's photometer to the Berlin Physical Society. It consists in the main of a small benzine lamp which is placed in a tube in front of a mirror and which illuminates a milk-glass plate adjustable in the tube. From this plate the light is carried to a totally reflecting prism and thence into the eye-piece, where it lights up one-half of the field of vision. The other half receives light from another milk-



glass plate placed behind the prism and toward the eye-piece, this plate being illuminated by the light to be measured. When the lights are of the same color, the measurements with this instrument are very exact, but if not, this precision could not be obtained. By placing a red, a green, and then a blue glass before the eye-piece and taking the mean, a closely approximate result may be obtained with this photometer. (Nature, March, 1886, xxxiii, 480.)

Subsequently Koenig described to the society a photometer sent to him from Dublin, which apparently far surpassed the Bunsen form of instrument. It consisted of two quadratic prisms of cast paraffin, connected to each other along one side. Between these two prisms was placed a piece of silver or of tin foil. When light fell on one of the prisms, this prism appeared clear white on account of the diffused reflections. This light was able to reach the other prism only through the metallic foil, and it therefore appeared dark. But when a second source of light was placed on the other side, the second prism appeared also bright. By displacement along a graduated scale the photometer could be brought into the position where both prisms appeared equally bright. A reading of the distances enabled the ratio of the intensities to be readily calculated. (Nature, May, 1886, xxxiv, 48.)

The Bakerian lecture before the Royal Society was on color photometry, and gave the results of Captain Abney's and Major-General Festing's researches in the direction of ascertaining whether it was practicable to compare with each other the intensity of lights of different colors. They found that by placing a rod in front of a patch of monochromatic light thrown on a screen, and by casting another shadow by the side of the first by means of a candle, the intensities of the two lights which illuminated the two shadows could be compared by what they term an oscillation method. As to the value of mixed light compared with its components, they give the following law: The sum of the intensities of two or more colors is equal to the intensity of the same rays when mixed. (Nature, April, 1886, xxxiii, 525.)

The committee appointed by the Trinity House to report on the merits of electricity, gas, and mineral oil as light-house illuminants have issued a valuable report giving an account of the investigations carried out under their directions and the conclusions they have arrived at, which are as follows: That the electric light as exhibited in the experimental tower at South Foreland has proved to be the most powerful light under all conditions of weather and to have the greatest penetrative power in fog; that for all practical purposes the gas and oil were equal; and that for the ordinary necessities of light-house illumination mineral oil is the most suitable and economical illuminant. They believe, however, that for salient headlands, important land-falls, and places where a very powerful light is required, electricity offers the greatest advantages. (Nature, January, 1886, xxxiii, 271; November, 1886, xxxv, 41, 60.)

## 2. *Reflection and refraction.*

A new method of reading small angular deflections, like those of galvanometers, for example, has been devised by D'Arsonval. It may be briefly described as the inverse of Poggendorff's (subjective) method. Usually the objective of the observing telescope forms at the conjugate focus a diminished image of the object—the scale as reflected in the mirror. D'Arsonval places the scale—a small one reduced by photography, giving tenths and twentieths of a millimeter—at this conjugate focus and obtains a magnified image of it reflected in the mirror and situated above the objective. This enlarged image, which is enormously displaced for small angular movements of the mirror, is again observed by an eye-piece bearing the usual cross wires. (*Nature*, April, 1886, xxxiii, 610.)

Mouchez has described a magnified form of mercury bath or artificial horizon which was constructed by Gautier for the Paris Observatory. A cylindrical cast-iron vessel, containing mercury, carries an axis at its center, on which is cut a screw-thread. A second and slightly smaller cast-iron vessel, having a similar screw-thread tapped through the bottom, is placed within the first, movable up and down on the screw-thread along the axis. This inner vessel is perforated with a small hole through which the mercury enters from the outer vessel to form the reflecting layer when the inner vessel is screwed down. This reflecting surface is found to be independent of the vibrations of the earth, but only under the condition that the screw be neither very tight nor very loose; since in the former case the two vessels are too firmly united and the vibrations are communicated from one to the other; and in the latter the inner vessel simply floats on the mercury, apparently assuming a condition of unstable equilibrium, the variations then producing in the mercury slow wave motions, thus preventing observation. The use of this new apparatus has thus far given excellent results at the Observatory. (*C. R.*, January, 1886, cii, 147.)

The results which have been obtained by Abbé, as the outcome of several years of experimenting to produce new and better kinds of optical glass, have now been published. These experiments began in January, 1881, and were prosecuted in connection with Schott, who took the chemical part of the work, Abbé himself taking the optical. The progress made justified the building a special laboratory in Jena in 1882, containing furnaces in which 10 kilograms of glass could be melted at once. Two problems occupied attention during 1883. The first was the production of pairs of kinds of flint and crown glass, such that the dispersion in the various regions of the spectrum should be for each pair as nearly as possible proportional. The second was the production of a greater multiplicity in the gradations of optical glass in respect to the two chief optical constants, refractive index and mean dispersion. In the fall of 1883 the two problems were regarded as sat-

isfactorily solved, the first with the result that achromatic lenses of a much more perfect kind than has ever been attainable have been produced, and as the outcome of the second a whole series of new glasses of graduated properties have been introduced into practical optics. Associating themselves now with the eminent microscopists Zeiss Brothers, new microscopic objectives have been made of the new glass to which Abbé gives the name apochromatic objectives. These lenses dry give better definition than the ordinary achromatic water immersion lens, higher eye-pieces may be used with them, and their visual and photographic foci are identical. The new glass is now produced in Jena on the large scale. (*Nature*, October, 1886, xxxiv, 622.)

Vogel has determined the variation of refraction with temperature both in glass and iceland-spar. The measurements were made by the method of minimum deviation, and the temperatures were comprised between  $12^{\circ}$  and  $260^{\circ}$ , the three hydrogen lines and the sodium line being used as points of reference. For  $12^{\circ}$  the first coefficient for the line D was for white glass  $123 \times 10^8$ , and for heavy glass  $190 \times 10^8$ , the second being  $106 \times 10^{10}$  and  $147 \times 10^0$ . For calc-spar the coefficient was for D,  $81 \times 10^8$  for the ordinary, and  $1020 \times 10^8$  for the extraordinary ray. (*Wied. Ann.*, xxv, 87; *J. Phys.*, January, 1886, II, v, 45.)

Bertrand has described a new refractometer, constructed especially for the optical study of rocks. (*J. Phys.*, May, 1886, II, v, 223.)

Gladstone, in a paper read at the Aberdeen meeting of the British Association, emphasizes the value of the refraction goniometer in chemical work, and suggests its use far more generally than has hitherto been the case. (*Nature*, February, 1886, xxxiii, 352.)

Chappuis and Riviére have studied the refractive index of air with a view to determine its variation with pressure. They find for their experiments at  $21^{\circ}$  and up to a pressure of nineteen atmospheres the following formula:  $n - 1 = 0.0003554 p (1 + 0.00058 p)$ , in which  $n$  is the index for the line D, and  $p$  the pressure in meters of mercury. Hence the index of air for the line D at  $0^{\circ}$  and 0.76 meter pressure is 1.0002927, identical with Mascart's value. (*C. R.*, June, 1886, cii, 1461.)

Rayleigh has measured directly the amount of light reflected from glass, as follows: Light from a cloud was passed through ground glass in the window of a darkened room, and made to fall at the polarizing angle on a plate of glass. The transmitted and reflected rays were conducted along different paths by a series of reflectors, but finally emerged side by side and of equal intensity. One of these reflectors was the glass to be tested, the light falling on it at an incidence almost perpendicular. This glass was now removed, and a single mirror was shifted so as to make the angles and points of incidence of the reflected ray on the several mirrors the same as before. The reflected ray was now brighter than the transmitted. To re-establish equality a disk with holes in a ring round the center was rotated in the path. The ratio of the sum of the breadths of the holes to the whole circumference of the



ring gave the percentage of the light reflected. A piece of optically-worked black glass reflected .058 of the total incident light. Repolishing in one case increased the light reflected from .04095 to .0445. (Nature, November, 1886, xxxv, 64.)

Howard Grubb has given a lecture at the Royal Institution upon telescope objectives and mirrors, their preparation and testing, with particular reference to his own methods and results. (Nature, May, 1886, xxxiv, 85.)

Stroh has described, in a paper to the Royal Society, a lantern combination by which stereoscopic effects may be obtained on a screen, as in ordinary projection. (Nature, May, 1886, xxxiv, 68.)

### 3. *Dispersion and color.*

The new spectrometer constructed by Hilger for the physical laboratory of University College, Dundee, has proved very satisfactory in its performance, reading directly to one second of arc and giving reliable results. Its construction is very simple. The collimator stands on a heavy pillar by itself; and the circle, which is divided to five minutes of arc on a ring 15 inches in diameter with six radial spokes, is carried on another pillar. The telescope, counterpoised, turns on the same axis but does not touch the circle at any point, and the reading is thus managed: From the telescope-bearing a double girder with a semicircular plate tied across its diameter with tubes of brass, stretches horizontally above the semi-circumference of the divided circle. To the ends of this girder are fixed two long-focus microscopes whose axes produced intersect the divided circle at the extremities of a diameter. They are read by means of a pointer and a spider-line micrometer whose head is divided into three hundred parts, each of which represents one second of arc. The microscopes are carried at such a height that they easily pass the collimator, and they can be read in any position. The light from the collimator passes entirely under the girder. (Nature, May, 1886, xxxiv, 92.)

Cornu has described a method by which he has succeeded in obtaining hydrogen spectrum tubes free from other substances. In the first place it is necessary that the mercury pump should be as far as possible from the apparatus which is to be traversed by the electric discharge, and that the communication between them should be established by many meters of helical tubes of glass, connecting with tubes of larger diameter containing first, fragments of sulphur to arrest the mercury vapor, and then copper turnings to take up the vapor of sulphur. All the parts of the apparatus should be sealed to each other by fusion. The hydrogen is produced by the electrolysis of dilute phosphoric acid, in a V-shaped voltameter, one of whose limbs communicates with the apparatus. The tubes are first exhausted, a few bubbles of gas are admitted and the rarefaction is continued. The spectrum shows spectra of carbon compounds. The battery current to the voltameter is



then reversed and ozone is passed into the apparatus to wash it out. After more or less repetitions of this process, the hydrogen spectrum is obtained pure. The original paper must be consulted for the details. (J. Phys., March, 1886, II, v, 100.)

In a subsequent paper Cornu gives a description of the method employed by him for photographing the ultra-violet portion of the diffraction spectrum obtained from these hydrogen tubes, and also describes the mode of measurement which he employed to obtain the wave lengths of the lines from the photographic plate. Ten of the lines thus measured have wave lengths almost identical with those measured by Huggins in the spectra of white stars. (J. Phys., August, 1886, II, v, 341.)

In studying the photographic spectrum of hydrogen, Cornu has observed that those groups of metallic lines which reappear periodically with a particular regularity belong to the category of those which reverse themselves. Moreover, they get nearer together, and diminish in intensity toward the more refrangible end of the spectrum. The spectra of aluminum and thallium are excellent examples. Now, in these metallic spectra certain series of lines spontaneously reversed, present sensibly the same law of distribution and intensity as that of the hydrogen lines. (J. Phys., March, 1886, II, v, 93; Nature, June, 1886, xxxiv, 105.)

Wiedemann has cautioned experimenters engaged in studying spark spectra against using for this purpose the spark of an induction coil, because of its composite character. The spectra produced by such a spark are multiple, their character changing with each of the partial discharges; so that one of these discharges may produce a line spectrum and another a band spectrum. Moreover, it is not the sum of these impressions that is observed, since the diminution of visual sensitiveness with time is felt in a way which is quite different for these sparks of differing intensity. Hence he prefers to use the Holtz spark for spectra. (Ann. Chim. Phys., January, 1886, VI, vii, 143.)

Bell, under Rowland's direction, has determined the wave lengths of thirty of the lines in the ultra-violet spectrum of cadmium. Seven of the lines measured were in the visible spectrum, and their wave lengths were determined by direct micrometric measurement. The others were fixed from measurements of their photographs. The author believes them correct to one fifty-thousandth part. (Am. J. Sci., 1886, III, xxxi, 426.)

Macé de Lepinay has sought to determine the absolute wave length of the line  $D_2$  by an ingenious and novel method, which consists in determining optically, by means of Talbot's bands, the dimensions of a quartz cube as a function of this wave length, and thence its volume in terms of this wave length, on the one hand. And on the other, in determining by the balance, from the loss of weight in water, its absolute volume in milliliters. The values obtained for the  $D_2$  line are, *in vacuo*,  $5.8917 \times 10^5$  (milliliters) $^{\frac{1}{3}}$ ; and in air  $5.8900 \times 10^5$  (milliliters) $^{\frac{1}{3}}$ . As

soon as the exact relation is known of the liter to the cubic decimeter, these values can of course be converted into centimeters. (*J. Phys.*, September, 1886, II, v, 411.)

Pickering has made an extended comparison of the photographed normal diffraction spectrum, published in 1873, by the late Henry Draper, and of Cornu's steel plate of the same region, with the photographs of the solar spectrum recently issued by Rowland. The results of the measurements show that the maps differ systematically, the wave lengths according to Draper's maps being too great for the lines of short wave length. Applying the proper corrections to the two maps of Draper and Cornu, the results agree closely with Rowland's. The mean difference for the seventy-six lines compared was 0.012, corresponding to about one eight-hundredth part of an inch upon the Draper map. It may therefore be assumed that the probable error of a wave length derived from the map of Draper will not exceed one one-hundredth of a unit, if the correction given be first applied. The wave lengths given on Cornu's map when thus corrected give an average deviation of 0.025. (*Am. J. Sci.*, September, 1886, III, xxxii, 223.)

Cornu has devised a simple but very ingenious method for distinguishing those lines in the sun's spectrum which are solar in their origin from those which are terrestrial. Fizeau had shown that there is a displacement of solar lines toward the red or the violet, according as the light came from the receding or the advancing edge of the sun. No such displacement occurs obviously if the lines are produced by absorption in the earth's atmosphere. This displacement is very minute, being only about  $\frac{1}{150}$  of the distance between the D lines as a maximum. But this Cornu has found quite sufficient. Using a Rowland grating, an image of the sun is formed on the slit of the spectroscope by a lens, to which a slight oscillatory motion can be given by the hand. To distinguish between a line of solar and one of terrestrial origin the line is brought near the vertical wire of the eye-piece, or better still, near one of those inevitable grains of dust which are always seen on the horizontal wire. The lever connected with the lens is then oscillated so as to bring alternately the two ends of the solar equator tangentially upon the slit. If the line is of terrestrial origin it remains absolutely fixed; if it is solar it oscillates with the lever. (*Nature*, July, 1886, xxxiv, 210; *Phil. Mag.*, November, 1886, V, xxii, 458.)

Cornu at once applied this new method to the study of the solar spectrum groups  $\alpha$ , B and A, and in an extended memoir has given a detailed account of the modifications employed in the research. Fifteen doublets were observed in the A group, thirteen in B, and eleven in  $\alpha$ . The paper is accompanied by an excellent plate giving all the lines of the groups drawn to scale, and indicating those which are of solar and those which are of terrestrial origin. These latter lines the author divides into two classes, one of which is probably due to moisture. (*Ann. Chim. Phys.*, January, 1886, VI, vii, 5.)

Crookes has examined the phosphorescent spectrum of erbia and finds that it consists of four green lines of wave lengths 5564, 5450, 5318, and 5197, respectively. Pure erbia is of a beautiful rose-pink color and when illuminated by sunlight or by the electric light it gives a spectrum of black lines as sharp and distinct as the Fraunhofer lines. (Nature, March, 1886, XXXIII, 474.)

Janssen in a paper to the French Academy, has given an account of his experiments at the Meudon observatory, upon the absorption spectrum of oxygen. The first point noticed was the absorptive action observed by Egoroff, producing the groups *a*, *A* and *B* of the solar spectrum. Besides this, however, another system of bands, much more difficultly resolvable, appeared as the pressure increased. The interesting fact about this system is the law according to which the absorption phenomena develop when the density and the thickness of the medium traversed are simultaneously varied. The increase of effect is much more rapid than the product of these factors; so that to represent the facts, thickness of the layer must be multiplied, not by the density itself, but by the square of the density. Thus these bands have been obtained in a tube 0.42 meter long, containing oxygen under a pressure of 70 atmospheres; while calculating from the results obtained with a tube 60 meters long, a pressure of 860 atmospheres would be required by the law of the product of length and density solely; in other words, under the condition that the beam shall traverse the same weight of matter. (C. R., June 1886, CII, 1352.)

Verneuil has given a method for preparing calcium sulphide, showing a violet phosphorescence on insolation. Twenty grams of dense lime, such for example as is obtained by the calcination of certain very hard sea-shells, are finely pulverized and intimately mixed with six grams of sulphur and two grams of starch. The mixture is then treated with 8 c. c. of a solution containing 0.5 gram bismuth subnitrate, 100 c. c. absolute alcohol, and a few drops hydrochloric acid, the liquid being added drop by drop. When the alcohol has mostly evaporated, the mixture is heated in a covered crucible to a cherry-red heat for twenty minutes. After cooling, the mass is pulverized and again calcined for fifteen minutes. (C. R., October, 1886, CIII, 600.)

## ELECTRICITY.

### 1. *Magnetism.*

In a paper read to the Royal Society Gemmell has described and given the results of a series of experiments on particular specimens of iron and steel, consisting of wires of soft Scotch iron, common wire, charcoal iron, and soft steel, and bars of cast-iron and of malleable iron. The object was to find the difference between these with respect to the intensities of their total and residual magnetization due to different degrees of magnetizing force. The results represent the effect of a cur-



rent gradually increased from zero to the maximum gradually diminished to zero again, and the same process repeated with a negative current. It was found that the charcoal iron had the highest magnetizability, and the soft steel the lowest; that of the soft Scotch iron approaching the former. As to retentiveness, on the other hand, the charcoal iron shows the least and the soft steel the greatest. Annealing the latter brings it very near the common wire in respect to magnetizability and retentiveness both. The cast iron specimens differ considerably also; the malleable bar shows a much higher magnetizability than the cast-iron ores, but its residual magnetization was so low that it could not be measured. (*Nature*, March, 1886, xxxiii, 473.)

In a series of experiments made to test the Ampère-Weber theory of magnetism, Lodge subjected various substances to the action of a magnetic field, first strong to magnetize it and then weak and reversible to test the magnetization produced. His observations have led him to the conclusion that most likely every substance possesses some trace of permanent magnetizability or retentivity. But in all these experiments there is a flaw; and that is that there is no guaranty that no trace of iron is present in the body operated on. (*Nature*, March, 1886, xxxiii, 484.)

Bidwell has studied the changes produced by magnetization in the length of iron wires under tension by means of a special apparatus so arranged that the effects of magnetization on rods and wires can be observed while they are under traction. Four specimens of iron were used—a wire of commercial iron 1.2<sup>mm</sup> in diameter, a strip of annealed charcoal iron, a piece of hard unannealed wire, and a wire of very pure soft iron. The results show (1) that under the influence of a gradually increasing magnetizing force the wire is at first elongated, then it returns to its original length, and finally it contracts; (2) that the maximum elongation diminishes as the load increases, but according to a different law for each quality of iron; (3) that the retraction due to a given magnetizing force is greater with heavy than with light loads; (4) that both maximum, elongation, and neutrality occur with smaller magnetizing currents when the load is heavy than when it is light; and (5) that the phenomena are greater for thin than for thick wires. (*Nature*, April, 1886, xxxiii, 597.)

The question of the influence of temperature upon magnetization has been examined by Berson. He concludes from the experiments of himself and others that iron, steel, nickel, and cobalt behave when magnetized in the same general way in regard to temperature. At first these metals take a magnetic moment, increasing with the temperature, pass through a maximum limit, and then decrease to zero. The only differences are (1) in the precise temperature corresponding to the maximum (about 220° for nickel), and (2) in the temperature at which the magnetic power disappears, 340° for nickel, cherry-red for iron and steel, the point of fusion of copper for cobalt. (*J. Phys.*, October, 1886, II, v, 437.)



Wiedemann has given a résumé of his researches made several years ago on the relation between the mechanical and magnetic properties of bodies, especially the torsional effects of magnetism, and has added certain new experiments in confirmation of his theory. (Wied. Ann., March, 1886; Phil. Mag., July, 1886, V, xxii, 50.) Bidwell has replied to Wiedemann, giving some experiments of his own which support Maxwell's theory. If a longitudinally magnetized wire be fixed at the south end, and if a battery current be passed through it from south to north, the free north end of the wire, as seen from the fixed end, will be observed to twist in the direction of motion of the hands of a clock. Maxwell explains this by the fact that the wire is magnetized both circularly and longitudinally, and that the resulting magnetization is in the direction of a right-handed screw round the wire. Since Jule has shown that an iron bar is increased in length and contracted transversely when magnetized, a spirally magnetized wire would necessarily twist. Bidwell has confirmed Barrett's observation that nickel contracts in length when magnetized. Hence on Maxwell's theory it should twist oppositely to an iron wire when spirally magnetized.\* This he finds to be the fact. Moreover, Bidwell's experiments on iron show that on increasing the magnetization of iron it ceases to elongate and then actually contracts. And further that if the iron wire is stretched, the contraction takes place with smaller magnetizing forces. Now, on magnetizing such an iron wire spirally, its free end can be made to twist in either direction by varying the current through the surrounding helix, and when the wire is loaded the reversal of the torsion occurs with smaller currents. (Phil. Mag., September, 1886, V, xxii, 251.)

Sack has experimented to determine the specific induction constants of magnets in magnetic fields of different strengths in order to fix the limits of the effect noticed by Lamont that the change of magnetism is greater when the force acts in opposition to the previous magnetization than when it strengthens it. He finds that the coefficients of weakening and strengthening are appreciably the same for fields in which the strength does not exceed 1.2. With stronger magnetic fields the magnitude of the constant of weakening which is produced by the magnetic field on closing is greater than the constant of strengthening. (Wied. Ann., 1886, No. 9; Phil. Mag., October, 1886, V, xxii, 386.)

Deprez has given the results of his experiments on the magnetic intensity of the field in dynamo-electric machines, and has observed that this intensity decreases much less rapidly than the distance between the pole pieces increases; the intensity of the field in one of his experiments diminishing to only one-half its value, while the distance separating the pole pieces was increased from 7.5 to 75 millimeters, or tenfold. (C. R., October, 1886. CIII, 712.)

Leduc has studied the variation in the resistance of bismuth when placed in a magnetic field, and finds that this resistance increases by more than 15 per cent. in a magnetic field whose intensity is 10,000

C. G. S. units. He proposes to use this variation in the resistance for the purpose of measuring the intensity of a magnetic field. This increase of resistance is in part due to the deviation of the equipotential lines, and hence the resistance should be divided by the cosine of this deviation. But since this coefficient does not exceed 1.005, the explanation of the greater part of the phenomenon is to be sought in the change of structure of the metal, which produces a deformation in the electric field of the metallic plate experimented on. (C. R., February, 1886, CII, 358.)

It has long been a question whether the intensity of terrestrial magnetism varies with the altitude; Humboldt, Kupffer, Forbes, Bravais, and Martin maintaining that it diminishes as the altitude increases, and Quetelet and Hartz holding the opposite view. Maurer has discussed a series of observations made simultaneously on the summit of the Sentis, 2,465 meters, and at the Polytechnicum in Zurich by himself and Bayer, lasting seventy-nine days, and has failed to find any sensible difference. Hence either the magnetic force is constant with altitude or the variation is very small. (Arch. Sci. Phys., Gen., XXII, 339; J. Phys., June, 1886, II, v, 290.)

Balfour, Stewart, and Schuster have discussed the phenomena of terrestrial magnetism, the former in a paper entitled "On the Cause of the Solar-diurnal Variations of Terrestrial Magnetism," and the latter in a paper "On the Diurnal Period of Terrestrial Magnetism." Both these investigators conclude that the cause of these variations lies in the upper atmospheric regions; and we can not imagine, says Stewart, such a cause to exist in any other form than that of a system of electric currents. (Phil. Mag., April, May, 1886, V, XXI, 349, 435; Nature, April, 1886, XXXIII, 614, 620.)

Krueger has proposed to determine directly the vertical intensity of a magnetic field by measuring the deflection which a disk suspended horizontally by means of a vertical wire in a solution of copper sulphate experiences when traversed in a radial direction by a current. The vertical intensity of the earth's magnetism at Göttingen thus determined was 2.2903 times the horizontal intensity; a value correct to the  $\frac{1}{5700}$  part. (Wied. Ann., XXVIII, 613; Phil. Mag., September, 1886, V, XXII, 311).

Nichols, following Remsen, has experimented to determine the chemical behavior of iron in the magnetic field. A definite quantity of powdered iron was introduced into a known weight of acid contained in a beaker placed between the poles of an electro magnet, and the rise of temperature noted in alternate experiments with the current off and on. Nitric, hydrochloric, and sulphuric acids were used, and also aqua regia. In all these both the speed of the reaction and the heat produced was greater in the magnetic field except in the case of sulphuric acid, where the heat was decreased. The prompt destruction of the so-called passivity of iron in the magnetic field was distinctly observed. (Am. J. Sci., April, 1886, III, XXXI, 272).

2. *Electric Generators.*

Dorn has proved that when tourmaline is electrified by heating it, the amount of positive electricity produced is precisely similar to the amount of negative electricity. The proof comes from the fact that if the tourmaline, after being heated, is brought inside a conducting but insulated hollow body, an electrometer connected with this body should show no signs of electricity as the crystal cools. No deflection was ever obtained which exceeded the uncertainty of the instrument employed. (Wied. Ann., November, 10, 1885; Phil. Mag., January, 1886, V, **xxi**, 78).

Hilliaret has described and discussed the action of an influence machine of the Wimshurst type constructed by Bréguet. If the charge of the machine is maintained from an external source the charge is theoretically limited; but if the machine is self-exciting, the charge diminishes in geometrical progression as the operations increase in arithmetical progression, and the excitation falls rapidly to zero. This is readily seen by putting the combs of the machine in contact. For practical use the author thinks this type of machine preferable to any other form. (J. Phys., May, 1886, II, v, 208.)

Budde has calculated the quantity of electricity carried by a chemical atom. Faraday showed that the quantity of electricity carried to the electrode by an atom of any electrolyte is directly proportional to its combining power or valence; and therefore that the quotient of this quantity divided by the valence is constant for all atoms. The authors therefore considers that this quotient, since it is the smallest quantity of electricity which can be set free from any chemical decomposition, represents an elementary electrical particle. To calculate it we must know: (1) the electro-chemical equivalent of an electrolyte, and (2) the absolute number of molecules contained in a unit mass of this substance. In the case of hydrogen, which is univalent, the electromagnetic value of the current which evolves 1 milligram of hydrogen per second is 957, and its electrostatic value  $957 v$ , or  $957 \times (3 \times 10^9)$ . One-half this sets free  $14 \times 10^{19}$  molecules or twice this number of atoms; these values being given in milligram-millimeter-second units. Dividing, we get for the value carried by any univalent atom 0.00000051 electrostatic unit. (Wied. Ann., **xxv**, 562; J. Phys., November, 1886, II, v, 523.)

Lodge's paper on the seat of the electromotive forces in the voltaic cell has called forth several replies. In one of these, Ayrton and Perry object to the assumption which he tacitly makes that there is a *prima facie* absurdity in acknowledging a considerable difference of potentials between two metals such as zinc and copper in contact with each other. Taking Lodge's definition of electromotive force, as already given by Maxwell, "the seat of the E. M. F. in any circuit is the place at which the circuit receives or gives up energy as distinct from heat due to resistance, and the amount of the E. M. F. is measured as



the amount of energy which enters the circuit per unit of electricity passing that point," and it is not possible to answer Lodge's question in any other way than that in which he has himself answered it. The real question at issue between them is quite another one. It is, is there an actual contact difference of potential between zinc and copper? a question which Ayrton and Perry answer in the affirmative. (Phil. Mag., January, 1886, V, XXI, 51.) In his reply Lodge confines his remarks to the thermo-electric views put forth in Ayrton and Perry's paper. He thus restates their assumptions, every one of which seems to him gratuitous and unsupported by experiment: (a) The characteristic function of a simple thermo-electric circuit is an expression for the Volta-effect between the metals of that circuit; (b) the Volta-effect of two metals varies with the temperature; (c) the total E. M. F. of a thermo-electric circuit is equal to the difference between the Volta-effects of its two metals at the temperatures of the hot and cold junction, respectively; (d) the specific heat of electricity falls greatly as it flows from copper to zinc and rises a nearly equal amount as it flows from zinc to acid; (e) the rate of variation of Volta-effect with temperature is a measure of the Peltier-effect at a junction; (f) heat is generated or destroyed at certain places in a circuit because electricity changes its capacity for heat there; (g) reversible energy actions may go on in a circuit when a current passes without producing heat or any other form of energy on the spot, and without either propelling or retarding the current. To accord with his own view, the above statements should be formulated as follows: (a) The characteristic function of a simple thermo-electric circuit represents *itself* and no other physical phenomenon that has yet been specially observed; (b) the Volta-effect of two metals certainly varies with temperature if the heat tends to oxidize one metal more than another, or in any other way to interpose a barrier between metal and active medium, but the fact has no thermo-electric interest whatever; (c) the total E. M. F. of a thermo-electric circuit is the sum of the forces in the different parts of that circuit, viz, at the junction and in the metals, and has nothing on earth to do with Volta's, or Crookes's, or Hall's, or anybody's else "effect," except Peltier's and Thomson's; (d, e) the Peltier-effect at a junction is a measure and consequence of the E. M. F. located there; (f, g) heat (or more generally energy) is generated or destroyed at places where the current does work or has work done upon it; *i. e.*, wherever it is opposed or assisted by an E. M. F., and nowhere else. (Phil. Mag., March, 1886, V, XXI, 263.) Ostwald, in a letter to Lodge, describes a method based on a statement by von Helmholtz, by which differences of potential, whether between two liquids or between a liquid and a metal, may be directly measured. (Phil. Mag., July, 1886, V, XXII, 70.)

Brown has communicated to the Royal Society an account of some important experiments on contact action. He maintains that the difference of potential near two metals in contact is due to the chemical



action of a film of condensed vapor or gas on their surfaces. Such a pair of plates is thus similar to a voltaic cell with its electrotype divided by a diaphragm of air or other gas; and it is the difference of potential of the films that is measured in "contact" experiments, the metals themselves being at one potential. His experiments were made with an electrometer having quadrants of the metals under consideration. A reversal of the electro-motive force takes place with pairs of copper-iron when hydrogen sulphide or ammonia is added to the air surrounding them; with silver-iron when hydrogen sulphide is added; and with copper-nickel when either ammonia or hydrogen chloride is added. Neutral or inert gases have little or no effect. By placing the (apparently) dry plates of copper and zinc in close proximity, so that their films were in contact, a permanent current was produced, which ceased when the metals touched or were separated to a certain distance. This "film-cell" could be polarized by sending a current through it from another battery. When the zinc plate of a Volta condenser was joined to the zinc quadrant of the electrometer and the copper of the condenser to the copper of the electrometer, on altering the capacity of the condenser an alteration of the difference of potential near the quadrants was produced. (*Nature*, December, 1886, xxv, 142.)

Knott has examined the resistance and thermo-electric properties of hydrogenized palladium. He finds that the electro-motive force in a circuit of pure and of hydrogenized palladium, the temperature of the junctions being  $0^{\circ}$  and  $100^{\circ}$ , is  $20 \times 10^4$  C. G. S. units, or 0.002 volt. If a palladium wire be hydrogenized for half its length by immersing that half in an electrolytic cell, and the ends of the apparently uniform wire be connected to a galvanometer, then on allowing a flame to play gently on the central portion of the wire a strong current is obtained, which increases to a maximum and then decreases to zero. (*Nature*, September, 1886, XXXIV, 462.)

Bidwell has exhibited to the Physical Society of London a cell with a solid electrotype thus constructed: Upon a plate of copper a layer of quite dry precipitated copper sulphide is spread. On this is placed a clean plate of silver, covered with a slight film of silver sulphide by pouring on it a solution of sulphur in carbon disulphide and evaporating the free sulphur by heat. On connecting the cell with a galvanometer a considerable deflection is obtained; far greater than, and in the opposite direction to, the deflection obtained with a silver plate not thus treated. The resistance of the cell was very great—6,500 ohms—but was greatly reduced by compression. The electro-motive force was 0.07 volt. (*Nature*, July, 1886, xxxiv, 211; *Phil. Mag.*, V, xx, 328; *J. Phys.*, July, 1886, II, v, 339.)

Toscani has demonstrated experimentally: First, that if in a battery cell both surfaces of the zinc are active, the contribution made by each of them to the general useful effect is in the inverse ratio of the square of their distance from the center of the inactive electrode; and, second,

that whatever be the number of surfaces of zinc in metallic communication in any given element, and whatever be their distances from the inactive electrodes each of these surfaces contributes to the general useful action very appropriately in the inverse ratio of the square of its distance from this electrode. (*Il Nuovo Cimento*, XVIII, 138; *J. Phys.*, December, 1886, II, v, 573.)

Hopkinson has presented a paper to the Royal Society on dynamo-machines, the purpose of the investigation being to give an approximately complete construction of the characteristic curve of a dynamo of a given form from the ordinary laws of electro-magnetism and the known properties of iron. Taking the curve already determined for wrought-iron and constructing a characteristic in this way, he has obtained a theoretical curve which agrees over a long range with the actual results of observations on a dynamo-machine more closely than any empirical formula yet published. (*Nature*, May, 1886, XXXIV, 20).

Gore has examined experimentally the effect of temperature upon the Peltier effect, and finds that with couples formed of bismuth-antimony, iron, German silver, and bismuth-silver, the total Peltier effect is greater in each case at the higher temperature than at the lower one, but with the antimony-silver couple the effects at the two temperatures were about equal. (*Phil. Mag.*, April, 1886, V, XVI, 359.)

### 3. *Electrical units and measurements.*

Lorenz has experimented to ascertain whether the resistances of liquid columns of the same length vary exactly in the inverse ratio of their sections when these sections are quite small. By measuring directly the resistances of non-capillary mercury columns and comparing them with those of capillary columns contained in tubes calibrated with the greatest care, he finds a difference in the latter of from 14 to 21 per cent. less than the calculated values. This difference, if real, is too small, however, to affect the absolute resistance except in the thousandth's place. The author's experiments fix the absolute value of the ohm at 105.93 centimeters; differing only by one-thousandth part from the conference unit. (*Wied. Ann.*, XXV, 1; *J. Phys.*, November, 1886, II, v, 539.)

Rayleigh has suggested certain criticisms on the details of the methods employed by Hinstedt in the determination of the ohm. He himself has found mercury contacts to be unreliable, and has substituted platinum contacts for them. Moreover, the question should be considered whether the axial magnetization of the needle does not alter under the action of a force having a sensible axial component. And, again, the methods of winding and measuring the primary and secondary coils introduce sources of error in his opinion. (*Phil. Mag.*, January, 1886, V, XXI, 10.)

In a paper on the Clark cell as a standard of E. M. F., Rayleigh has discussed the relative advantages of various modes of preparation. The

greatest errors arise from the liquid failing to be saturated with zinc sulphate, in which case the E. M. F. is too high. The opposite error of supersaturation is also sometimes met with. If these errors are avoided, as may easily be done; if the mercury be pure, (profusely distilled *in vacuo*); and if the paste be neutralized either originally with zinc carbonate or by allowing a few weeks to elapse (during which the solution is supposed to neutralize itself), the electromotive force appears to be trustworthy to one-thousandth part. This conclusion is based on the examination of a large number of cells prepared by the author and by other physicists. (*Nature*, February, 1886, XXXIII, 357.)

Lippmann has devised an absolute spherical electrometer, which consists essentially of an insulated metallic sphere raised to the potential the value of which we desire to know. This sphere is so constructed as to divide into two hemispheres, which are movable with respect to each other, and which, when the system is electrified, repel with a perfectly definite force. It can easily be shown that this force is one-eighth of the square of the potential of the sphere. To measure this force, one of the hemispheres is fixed, the other is suspended by a tri-filar system—three vertical wires of equal lengths. When repulsion is produced the movable hemisphere can be displaced only parallel to itself; the three wires then make a small angle with their original vertical position, which angle is measured by the mirror method. The product of the weight of the movable hemisphere by the tangent of the angle of rotation is the force. In the improved form of this instrument the two hemispheres are contained within a concentric spherical envelope, which is connected with the earth. By this means not only is the sensitiveness increased, but the system is protected from air currents as well as from extraneous electrical influences. (*C. R.*, March, 1886, CII, 666; *Phil. Mag.*, July, 1886, V, XXII, 79; *J. Phys.*, July, 1886, II, v, 323.)

Bichat and Blondlot have described two forms of absolute electrometer, the one adapted to give continuous indications the other for high potentials. In the former instrument, the attraction between two concentric cylinders is measured. One of these is fixed, the other is attached to the beam of a balance; the other end of the beam carries a disk moving in a cylinder to damp the oscillations. In the other electrometer the movable cylinder is supported at the middle of its length upon a knife-edge attached to the beam; it is balanced by adjustable counterpoises. The upper portion of this cylinder is surrounded by a second and hollow cylinder, which when electrified attracts the inner cylinder upward. The lower end of the cylinder carries a scale-pan and a damping cylinder of paper moving in a glass cylinder of slightly larger diameter (*C. R.*, March, CII, 753; July, 1886, CII, 245; *J. Phys.*, II, v, 325, July; 457, October.)

Kolacek has suggested a method of using the gold-leaf electroscope so as to get a definite relation between the angle of divergence of the leaves and the difference of potential between the leaves and the enve-



lope. The leaves were 8<sup>cm</sup> long, and were projected, magnified fifteen times, upon a screen divided into centimeters. The reading of the distance was made about twenty seconds after the first impulse; and the deflection is proportional to the square of the potential difference. The condenser employed consisted of two copper plates 7<sup>cm</sup> in diameter, the one screwed on the electroscope only being varnished. The values obtained for Daniell cells, for bichromate cells, and for copper-zinc potential difference are satisfactory. (Wied. Ann., No. 7; Phil. Mag., August, 1886, V, xxii, 228.)

Fitzgerald has devised a new galvanometer. Its peculiarities are (1) the arrangement by which the coils can be measured in their place; (2) the arrangement by which the circle is read with a microscope by reflection mirrors attached to the magnet when the instrument is used either as a sine or tangent galvanometer; and (3) an arrangement by which a spot of light reads the tangents of deflection. The first advantage is secured by leaving the two pairs of short and long coils wound in grooves, closed in outside by a glass plate, through which they can be seen, and the external and internal diameter of each layer of wire measured; the transverse diameter, by looking through small holes left in the ring that covers the coils outside. The reading is effected by viewing a scale engraved on the inside of a horizontal ring surrounding the needle by reflection in two right-angled prisms attached to the needle, which reflect opposite sides of the scale. The corresponding lines in the two maps, which differ by exactly 180°, is the line at right angles to the line of intersection of the reflecting planes of the prism. The exact position of that line can be read by means of a micrometer in the eye-piece of the microscope. The horizontal graduated ring is attached through the vertical axis on which the coils, etc., turn, to the base of the instrument, and so the same circle does for reading when the instrument is used as a sine galvanometer. By means of a small mirror attached to the needle at 45° to the line of suspension a spot of light can be reflected through the glass side of the instrument to a scale, and then a uniform scale represents the tangents of the deflections. (Nature, March, 1886, xxxiii, 455.) Carey Foster has noted the fact that Bertin, in 1869, showed that the sensitiveness of the tangent galvanometer for strong currents may be increased and the usable range of deflection doubled by placing the circle in a vertical plane inclined at an angle of 45° to the magnetic meridian. (Nature, October, 1886, xxxiv, 546.) Gray has described a modified form of sine galvanometer, in which the coil consists of a single layer of wire wound on a tube of comparatively small diameter, say, ten centimeters or less, and of great length, movable about a vertical axis, and carrying within it and at its center the needle attached to a delicately suspended mirror. (Phil. Mag., October, 1886, V, xxii, 368.) Thompson has described a modified form of Maxwell's galvanometer. A light frame of copper, upon which is a coil of wire, is suspended between the poles of a horseshoe



magnet, and a piece of soft iron is placed within the coil, but free from it, which concentrates the magnetic force between the poles. The coil is suspended by two silver wires, by which it is in connection with two binding screws on the base of the instrument. This galvanometer is extremely simple in adjustment and is very dead beat; it has also the advantage of being affected to an inappreciable extent by neighboring magnets and currents with a current in its own coils; when no current is traversing it, it is of course quite unaffected. (*Nature*, April, 1886, XXXIII, 574.)

Lalande has devised forms of voltmeters and ammeters which might be called electrical arcometers. They consist of a bundle of soft iron wires placed inside a metal arcometer, which is immersed in a glass cylinder full of water, and round which is coiled the wire through which passes the current to be measured. In the apparatus as constructed a displacement of 10 centimeters corresponds to a strength of from 10 to 25 amperes at pleasure, or to a difference of potential of 100 volts. (*C. R.*, CI, —; *Phil. Mag.*, February, 1886, V, XXI, 163.)

Blyth has described a new form of current-weigher for the absolute determination of the strength of an electric current. In one of his instruments a current of 1 ampere produces an attraction equal to a weight of .04818 gram. (*Nature*, September, 1886, XXXIV, 508.)

Pellat has applied the same principle to the construction of an electro-dynamometer, by means of which the absolute value of a current may be determined within one two-thousandth of its value. (*C. R.*, December, 1886, CIII, 1189.)

Bidwell has described an improved form of Wheatstone's rheostat, which is of great use where it is important to adjust a resistance to a nicety or to cause a continuous variation. (*Nature*, May, 1886, XXXIV, 70; *Phil. Mag.*, July, 1886, V, XXII, 29.)

Roiti has constructed an electro-calorimeter, formed of two Bréguet spirals placed the one above the other; one having the silver on the outside, the other on the inside. Their opposite ends are fixed and receive the current. Their free ends are connected together and with a metallic index, which they tend to turn in the same direction. A comparison with the electric thermometer of Riess showed for the electro-calorimeter an equal sensitiveness. This instrument was employed in the electrical exhibition at Turin in measuring the Gaulard and Gibbs secondary generator, and with satisfactory results. (*Il Nuovo Cimento*, XVIII, 1; *J. Phys.*, December, 1886, II, v, 576.)

Ayrton and Perry have communicated a valuable paper to the London Physical Society on the construction of voltmeters, particularly on the best method of winding. (*Phil. Mag.*, February, 1886, V, XXI, 100.)

Wassmuth has suggested that when a galvanometer needle is made astatic by an auxiliary magnet placed at a distance from it, there should be placed in the vicinity of the magnet and perpendicular to its direction a plate of iron. The sensibility of the galvanometer is notably

changed by displacing this plate; and this without putting the needle in a position of unstable equilibrium. Moreover, the influence of terrestrial magnetism on a galvanometer may be materially diminished by surrounding it with a ring of iron. (Anz. Ak. Wien, 1885, 148; J. Phys., May, 1886, II, v, 242.)

Carhart has observed that the equation expressing the electrical energy absorbed by a motor per second as the product of the counter-electromotive force and the current  $E_1^2 - EE_1 = -R W$ , is an equation of the second degree, and therefore represents a conic section. On applying the proper criterion he finds that the locus of this equation is a hyperbola. Plotting the curve, he draws important inferences from it, and shows that Jacobi's law of maximum rate of working applies only under the condition of a constant electromotive force. (Am. J. Sci., February, 1886, III, xxxi, 95.)

Mendenhall has repeated and confirmed his experiments on the diminution of the resistance of soft-carbon disks with pressure. With a rod of hard carbon 12<sup>cm</sup> long and 1.5<sup>cm</sup> in diameter, with plated contacts inside of the ends, he observed a decreased deflection whenever the rod was compressed in a vise. The soft-carbon disk was made to form a partition between the two halves of a U tube, and, mercury being poured in so as to entirely cover the surfaces of the carbon, the ends of the tubes were closed. On then blowing in through a rubber tube connected laterally to each leg pressure could be produced on the carbon disk and the effect on the current passing through the disk noted. All the experiments without exception showed great diminution in the resistance of the disk by increase of pressure; this resistance in one case falling to one-half when the pressure was increased by 5<sup>cm</sup> of mercury. (Am. J. Sci., September, 1887, III, xxxii, 218.) Tomlinson has published a note on these experiments, stating that he prefers to believe that the change does not take place in the specific resistance of the carbon itself, but is due to better surface contact; erroneously assuming that the Edison soft-carbon disks are formed by compressing a mixture of lamp-black with gum-water. (Phil. Mag., November, 1886, V, xxii, 442.)

#### 4. *Electric spark and electric light.*

According to the hypothesis of Edlund, a perfect vacuum is a good conductor of electricity, and the resistance of a gaseous column more or less rarefied is composed of two terms, one of which represents the resistance proper of the gas which diminishes with the pressure, the other a resistance of which the surface of the electrodes is the seat, and which varies according to an entirely different law, increasing as the density of the gas diminishes and becoming so great at the lowest pressures that can be produced artificially as to have given the impression that a vacuum is an insulator. Homén, under Edlund's direction, has made a series of measurements on the resistance of air columns

under varying lengths and pressures. He finds (1) that the resistance proper of the air is sensibly independent of the section of the tube, varies proportional to the pressure nearly, and ceases to be measurable for very low pressures; (2) that the resistance at the electrodes increases more and more rapidly as the pressure diminishes, becomes strong enough at the lowest pressures to prevent the electricity from entering the gas. According to Goldstein the seat of this resistance is the surface of the negative electrode; according to Hittorf it is in the luminous aureole which surrounds it, while Wiedemann places it in the dark space which appears at low pressures. (Weid. Ann., xxvi, 85; J. Phys., November, 1886, II, v, 543.)

In his memoirs upon comets, Faye has stated his belief that incandescent bodies are endowed with an actual repulsive force, and he gives an experiment which he thinks proves this assumption. Wesendonck has repeated and varied Faye's experiment, heating the platinum strip to incandescence, either by a current or by a flame, and modifying the form of the apparatus, the nature of the gas within it, and the pressure; and he concludes that all the phenomena obtained can be explained either by the expansion of the gas in the vicinity of the incandescent platinum or by the lateral passage of a part of the discharge through the platinum strip; and this without resort to repulsion. (Weid. Ann., xxvi, 81; J. Phys., November, 1886, II, v, 544.)

Righi has photographed the electric spark in air and in water, under various conditions. The sparks in water were 7 or 8<sup>cm</sup> long, rose-red, with weak discharges, white and very brilliant with strong ones. They have no aureole. They are often ramified as in air and present over their whole length small sparks, starting to the right and left like a sort of down. Beautiful photographs have also been obtained of the aureoles around the positive and negative electrodes, when the spark has not tension enough to jump. Sometimes two images of the aureole are seen, differing in brilliance, projected the one upon the other, the photographic impression at the point of crossing being paler than the rest of the most distinct image. This the author explains by supposing absorption at a lower temperature by the layers nearest the plate of the light produced by those back of them. (Il Nuovo Cimento, xviii, 49; J. Phys., December, 1886, II, v, 575.)

Kayser has photographed successfully lightning discharges. He has called attention to one particular discharge formed of four flashes of different sizes, parallel through all their sinuosities, decreasing gradually in length and brilliance from the first to the fourth. He regards it as an oscillating discharge between a cloud and the earth. He estimated the total discharge to have occupied less than a half second. (Weid. Anns., xxv, 131; J. Phys., November, 1886, II, v, 525.)

Emmott and Ackroyd have exhibited to the London Physical Society an electric-light fire-damp indicator. It consists of two incandescent lamps, one with colorless, the other with red, glass, the circuit being so



arranged that in an ordinary atmosphere the colorless lamp alone shines, but in fire damp this goes out and the red one lights up. This is effected in a simple manner by the motion of a mercury contact opening the lower part of a curved tube, one end of which is open and the other connected with a porous pot of unglazed porcelain, the motion of the mercury being due to the increased pressure in the pot caused by diffusion. (*Nature*, July 1886, xxxiv, 210; *Phil. Mag.*, August 1886, V, xxii, 145.)

Von Lang has measured directly the counter electro-motive force of the voltaic arc as follows: Two separate sets of light apparatus are arranged symmetrically in the circuit of a Benson battery so that the middle of the battery and the middle of the conductor uniting the two lamps are at the same potential. By the aid of a Wheatstone bridge the resistance of the two portions of the circuit are determined; first when both lamps are in action, again when the carbons have been replaced by resistances which restore the current to its primitive value. The half-difference of the two values thus obtained gives the resistance, which is compensated by the counter electro-motive force of one of the voltaic arcs. This is readily calculated by multiplying the difference obtained by the current strength. The value thus found is 38.6 volts. (*Anz. Ak. Wien*, 1885, 89; *J. Phys.*, May, 1886, II, v, 239, November, 542.)

Cross and Shepard have also studied the counter electro-motive force of the arc, under various conditions. They conclude: (1) That there is a definite inverse electromotive force for the whistling arc, whose value is approximately 15 volts; (2) that the inverse electro-motive force for both the silent and whistling arcs diminishes slowly as the current increases; (3) that the inverse electro-motive force, at least for the whistling arc, is less for the inverted than for the upright arc; (4) that the great change in equivalent resistance which occurs when volatile salts are introduced into the arc is chiefly due to a large fall in the inverse electro-motive force, although there is at the same time a marked diminution in the conductive resistance; (5) that the diminished total resistance of the arc in rarefied air is due solely to a diminution in the conductive resistance; and (6) that there is some evidence to show that with considerable reduction of pressure there is a slight increase in the inverse electro-motive force. (*Proc. Am. Acad.*, 1886, xxii, 227.)

Carhart has examined the question of electrical surface transmission and concludes there is no sufficient scientific basis for making lightning conductors of large surface, and that large sectional area is essential to ample conductivity. (*Am. J. Sci.*, April, 1886, III, xxxi, 256.)

Douglass has suggested the use of fluted carbons 50<sup>mm</sup> in diameter for light-house electric lighting. When in use no crater is formed in either of the carbon points and their form is all that can be desired for utilizing fully the maximum light of the radiant arc. He estimates that the actual gain in light by their use is not less than 10 per cent. (*Nature*, July, 1886, xxxiv, 209.)



## NECROLOGY OF PHYSICISTS, 1886.

- DRAPER, JOHN CHRISTOPHER, professor of chemistry in the medical department of the University of the City of New York. Known as a writer on optical subjects and the author of a text-book on medical physics. Died in New York, December 20, 1885, in his fifty-first year.
- JAMIN, J., perpetual secretary of the Academy of Sciences, author of a "Cours de Physique," and well known for his investigations in physics, especially in optics and electricity. Died in Paris, of heart disease, February 12, 1886, aged seventy-three years.
- GUEROUT, AUGUSTE, secretary of the board of editors of *La Lumière Électrique*. Known as a writer on electrical subjects. Died in Paris, from consumption, in March, 1886, at the age of forty years.
- MELSENS, L. H. F., member of the Royal Academy of Sciences, Belgium. Known for his scientific memoirs, especially on lightning protection. Died in Brussels, April 18, 1886.
- MANN, R. J., president of the Meteorological Society. Known as a writer on meteorological subjects, particularly on the protection of buildings from lightning. Died in London, in August, 1886, aged sixty-nine years.
- DUBOSEQ, J., constructor of physical apparatus, especially optical. Assisted Léon Foucault in all his constructions, particularly his electric lamp. Died in Paris, in October, 1886.
- GUTHRIE, FREDERICK, F. R. S., lecturer on physics in the Royal School of Mines. Well known for his physical researches, especially those on the cryohydrates and eutexia. He was the author of several text-books. Died in London, of cancer of the throat, October 21, 1886, at the age of fifty-three.
- PIERIE, VICTOR, professor of physics in the University of Vienna. Died in his laboratory, of apoplexy, on the 30th of October, 1886.
- BEAULIEU, JOHN THEOPHILUS, F. R. S., a general in the engineer corps of the Indian army for many years. He inaugurated the system of magnetic observations in India. Died in London, in November, at the age of eighty-one years.

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## CHEMISTRY IN 1886.

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### GENERAL AND PHYSICAL.

*Nature and Origin of the Elements.*—Mr. William Crookes, F. R. S., president of the chemical section of the British Association for the Advancement of Science, gave an address at the Birmingham meeting in September, in which he undertook with great skill and learning to adapt the doctrine of evolution to the chemical elements. After glancing at the difficulty of defining an element he noticed the revolt of many physicists and chemists against the ordinary acceptance of the term. He next considered the improbability of their eternal self-existence or their origination by chance. He suggested as a remaining alternative their origin by a process of evolution, like that of the heavenly bodies according to Laplace. In this connection he remarks: "This building up or evolution is above all things not fortuitous; the variation and development which we recognize in the universe run along certain fixed lines, which have been preconceived and foreordained. To the careless and hasty eye design and evolution seem antagonistic; the more careful inquirer sees that evolution, steadily proceeding along an ascending scale of excellence, is the strongest argument in favor of a preconceived plan." Mr. Crookes then shows that in the general array of the elements, as known, a striking approximation is seen to that of the organic world, though he admits this apparent analogy must not be strained.

He then reviews indirect evidences of the decomposition of the so-called elements, taking into consideration the light thrown upon this subject by Prout's law and by the researches of Mr. Lockyer in solar spectroscopy. He also reviews the evidence drawn from the distribution and collocation of the elements in the crust of our earth. He gives due consideration to Dr. Carnelly's weighty argument in favor of the compound nature of the so-called elements from their analogy to the compound radicals.\*

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\* See Smithsonian Report for 1885, Chemistry.



A study of a special method of illustrating the periodic law, proposed by Prof. Emerson Reynolds, leads Mr. Crookes to a theory of the genesis of the elements.

He supposes in the very beginnings of time, before geological ages, the existence of a primordial matter, which he names *protyle* ( $\pi\rho\omicron$  and  $\delta\lambda\eta$ ). He imagines a "primal stage, before even the sun himself had consolidated from the original protyle, when all was in an ultra-gaseous state, at a temperature inconceivably hotter than anything now existing in the visible universe; so high, indeed, that the chemical atoms could not have been formed, being still far above their dissociation points. In the course of time some process akin to cooling, probably internal, reduces the temperature of the cosmic protyle to a point at which the first step in granulation takes place—matter, as we know it, comes into existence, and atoms are formed. As soon as an atom is formed out of protyle it is a store of energy potential and kinetic. To obtain this energy the neighboring protyle must be refrigerated by it, and thereby the subsequent formation of other atoms will be accelerated. But with atomic matter the various forms of energy which require matter to render them evident begin to act; and amongst others that form of energy which has for one of its factors what we now call atomic weight. The easiest formed element, the one most nearly allied to the protyle in simplicity, is first born. Hydrogen (or perhaps *helium*), of all the known elements the one of simplest structure and lowest atomic weight, is the first to come into being. For some time hydrogen would be the only form of matter (as we now know it) in existence, and between hydrogen and the next formed element there would be a considerable gap in time, during the latter part of which the element next in order of simplicity would be slowly approaching its birth point. Pending this period we may suppose that the evolutionary process, which soon was to determine the birth of a new element, would also determine its atomic weight, its affinities, and its chemical position."

Space at our command forbids our following the author further in his sketch of the genesis of the elements. The application of radiant-matter spectra to the theory is a weighty contribution to the ingenious argument so interestingly portrayed, and one which the author alone is qualified to advance. (*Nature*, xxxiv, 423.)

*Valency and the Electrical Charge on the Atom*, by A. P. Laurie.—The author points out the bearing of the facts of electrolysis on the true nature of valency. Helmholtz has shown that it follows from Faraday's experiments on electrolysis, that while a monovalent atom carries to the electrode one charge of electricity, a divalent atom carries two charges of electricity; in other words, electrolysis proves that differences of valency mean differences in the electrical charge on the atom. The author remarks that many elements vary in valency; copper, for instance, forms two very unlike series of compounds, one in which it is monova-

lent, and one in which it is divalent; since, however, we may pass from cuprous to cupric compounds we are able to alter the electrical charge on the atom, increasing it by some simple multiple. He remarks further that in the case of the two copper chlorides their heat of formation per chlorine atom is not very different. It is well known that the heat of formation of a salt approximates to the heat of formation as calculated from the electro-motive force developed when that salt is formed in a voltaic cell; hence from the heat of formation of the cuprous or cupric chloride, an approximate calculation can be made of the difference of electric potential between the copper atom and the chlorine atom in the two salts. But since the heat of formation per chlorine atom is nearly the same, the difference of potential is nearly the same in both salts; whence it follows that in doubling the electric charge on the copper atom the potential is not also doubled. This signifies, then, that the capacity of the atom for electricity is increased at the same time. Laurie then suggests that the idea of atomic weight may perhaps be replaced by the idea of charges of electricity; that the atoms of the elements are of the same weight and probably of the same "stuff," and that only two things condition the properties of the atom, namely, its electrical charge and its electrical potential. If this be accepted Mendelejeff's table becomes a statement of the periodic relationship between these. (*Nature*, xxxv, 131.)

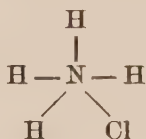
*Water of Crystallization*, by W. W. J. Nicol.—When a hydrated salt is dissolved does it retain its water of crystallization or does this latter cease to be distinguishable from the solvent water? Both views have been held by chemists, but the author shows that the science of thermochemistry clearly demonstrates that water of crystallization can not be attached to the salt in solution. The argument will be found in the original note. (*Chem. News*, LIV, 53.)

*A Law of Solubility*, by William Ackroyd.—The author announces as a new law of solubility the following: "A body will dissolve in a solvent to which it is allied more readily than in one to which it is highly dissimilar." Thus organic bodies, generally speaking, require organic solvents, inorganic bodies inorganic solvents. Exceptions to the law are admitted by the author. (*Chem. News*, LIV, 58.)

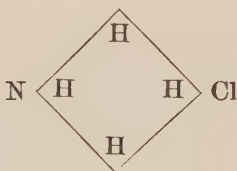
*Chemical Affinity and Solution*.—In a paper before the Royal Society of Edinburgh, presented in 1878, W. Durham stated his opinion, based on the results of many experiments, that chemical combination, solution, and suspension of solids, such as clay, in water, differ in degree only, and are manifestations of the same force; that there seems to be a regular gradation of chemical attraction from that exhibited in the suspension of clay in water up to that exhibited in the attraction of sulphuric acid for water, which we call chemical affinity.

More recently Mr. E. Durham endeavored to show that the theory of

valency as usually held is incorrect in assuming chemical affinity to act in units or bonds, and insufficient to account for the various phenomena of varying atomicity, or valency, molecular compounds, crystallization, solution, alloys, etc., and that all these varied phenomena are simply due to the chemical affinity of the elementary atoms; the difficulties disappear if the idea of indivisible units of chemical affinity is abandoned. This view is illustrated by reference to the compounds  $\text{HCl}$ ,  $\text{NH}_3$ , and  $\text{NH}_4\text{Cl}$ . In  $\text{HCl}$  we have two monovalent elements combined and their chemical affinities completely neutralized or satisfied. In  $\text{NH}_3$  we have N considered as a trivalent element satisfied with three monovalent elements. Now these two completed or satisfied compounds combine with one another to form the third compound  $\text{NH}_4\text{Cl}$ . This is usually explained by regarding the N as acting with pentavalent force, and the compound is represented thus:



Durham thinks this explanation most unreasonable and incredible, because it supposes that N, which has usually such a weak affinity for Cl, can nevertheless decompose the  $\text{HCl}$  into its constituent atoms, and fix the atom of Cl to itself. While on the other hand the Cl leaves the H, for which usually its affinity is so great, and unites itself to the N, for which usually its affinity is so small. Durham explains this action simply thus: The affinity of the Cl acts on all the four atoms of H, and the affinity of the N does the same; and thus the whole molecule is held together, and may be represented thus:

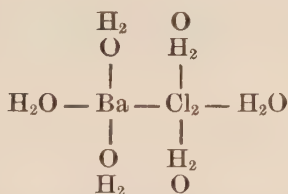


Mr. Durham finds that chemists are apparently coming more and more to agree with his views, and quotes Pattison Muir's "Principles of Chemistry" to substantiate this. By reference to Thomsen's researches in thermo-chemistry, he obtains data which he regards as demonstrating the truth of his views on the subject of solution. He regards solution as due to the affinities of the constituent elements of the body dissolved for the constituent elements of the solvent; thus  $\text{NaCl}$  dissolves in water on account of the affinity of the Na for the O and of the Cl for the H. These affinities are not strong enough to cause double decomposition,

and therefore an indefinite compound is formed, which we call a solution. On examining the heat of formation of chlorides and of oxides (as obtained by Thomsen) he finds that that oxide (or chloride) which has the greatest heat of formation is the least soluble. Thus the heat of formation of the chlorides of Mg, Ca, Sr, Ba increases in the order of the metals as given; and the solubility of the chlorides of these metals decreases in the order given; again the heat of formation of the oxides increases in the order Ba, Sr, Ca, Mg, whereas the solubility of these oxides decreases in the same order.

Mr. Durham contends that if his views be admitted, crystallization can be satisfactorily explained, and regular structure follows:

In such a compound as  $\text{BaCl}_2 \cdot 6\text{H}_2\text{O}$ , the atoms of the molecule must be arranged somewhat in this way:



His theory affords also a simple explanation of the freezing of water: In water attraction exists between the  $\text{H}_2$  of one molecule and the O of another, and *vice versa*; now, if the heat of the liquid be diminished sufficiently, that attraction will cause cohesion of the molecules, and will produce solid water or ice, the regular structure of which is caused by the symmetrical arrangement of the atoms. Hence the various conditions of matter, solid, liquid, and gaseous, may be due to the chemical affinity of the constituent atoms, modified in various ways by the kinetic energy of the system.

These views are opposed to that which depicts chemical affinity as a sort of arbitrary force acting in units or bonds; on the contrary, affinity acts between all atoms of matter, whether of the same or different kinds, in varying degrees of intensity and quantity, producing combinations of more or less stability, graduating from the so-called mechanical mixture of clay and water up to the irresolvable molecules of the permanent gas, condensing by its action the gas into the liquid, and the liquid into the solid. In short, there are no hard and fast lines in nature, but every phenomenon graduates by almost imperceptible degrees into another. (Nature, XXXIII, 615.)

*A General Method for the Determination of Molecular Weights*, by F. M. Raoult.—The author has previously shown that the molecular weights of organic bodies soluble in water can be determined by the amount of reduction in the temperature of its freezing point. Further investigations now enable him to generalize this method and to main-



tain that the molecular weights of all bodies, inorganic or organic, can be determined in like manner, provided the bodies are soluble in some liquid capable of assuming a solid state at a temperature ascertainable with accuracy. The menstruums employed are acetic acid, benzene, and water. The methods of procedure and of calculation will be found in the original paper. (Ann. Chim. Phys. [6], VIII, 317.)

*On the Constitution of Acids*, by W. A. Dixon.—The author proposes a theory explaining the fact that some acids form with the alkali metals alkaline hydrogen salts, whilst the similar salts of other acids are acid. He suggests that, as is the case with organic compounds, the hydrogen in inorganic acids exists in combination in two states, first, with oxygen as hydroxyl, and, second, with two oxygen atoms as oxyhydroxyl. He thinks that where both these exist in one acid the hydrogen of the oxyhydroxyl is invariably replaced first, and therefore the principal acid function is in connection with oxyhydroxyl. Examples are taken from

the acids of phosphorus; orthophosphoric acid is probably  $\text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OH} \\ \diagdown \\ \text{OH} \end{array}$ ,

because the acid itself has strong acid properties; but these are immediately neutralized by the replacement of the hydrogen of the oxyhydroxyl group by sodium, while the replacement of the hydrogen of one hydroxyl group gives a salt having an alkaline reaction. In like man-

ner phosphorous acid may have the composition  $\text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OH} \\ \diagdown \\ \text{H} \end{array}$ , and is dibasic;

hypophosphorous acid is  $\text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{H} \\ \diagdown \\ \text{H} \end{array}$ ; and pyrophosphoric acid,  $\text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OOH} \\ | \\ \text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OH} \end{array} \end{array}$ .

Sulphuric acid may be  $\text{S} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OOH} \end{array}$  and sulphurous  $\text{S} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{OH} \end{array}$ , the first forming acid and the second alkaline hydrogen salts with the alkaline metals. Hyposulphurous acid may be  $\text{S} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{H} \end{array}$ , and is monobasic. Nitric acid may be  $\text{N} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{O} \end{array}$ ; metaphosphoric,  $\text{P} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{O} \end{array}$ , and chloric,  $\text{Cl} \begin{array}{l} \text{OOH} \\ \diagup \\ \text{O} \end{array}$ . (Phil. Mag. [5], XXI, 127.)

*The Re-actions between Metals and Acids*, by Henry E. Armstrong.—In the course of a paper before the Chemical Society of London on the "action of metals on acids," in which experiments were described at-

tempting to obtain evidence of definite compounds of metals in alloys by dissolving the alloys in a liquid capable of acting on both metals and determining the electromotive force between the alloy and a less positive metal, the author made the following remarks: "With reference to the action of metals on acids generally it is probably impossible for the chemist to pronounce definitely in favor either of the modern view that the metal directly displaces the hydrogen of the acid, or of the older view that the metal displaces the hydrogen from water, the resulting oxide and the acid then interacting to form a salt; the decision of this question must apparently depend upon the determination of the nature of the phenomena during electrolysis of an acid solution. If the acid alone be the electrolyte, then doubtless the modern view is the correct one; but if both water and acid are electrolyzed, and in proportions which vary according to the conditions, then both the old and new views of the nature of the action between a metal and the solution of an acid are correct, and the two kinds of change may go on side by side." (Chem. News, LIII, 212.)

*Chemical Behavior of Iron in the Magnetic Field*, by Edward L. Nichols.—When finely-divided iron is placed in a magnetic field of considerable intensity and exposed to the action of an acid, the chemical reaction differs in several respects from that which occurs under ordinary circumstances. The cause of one such difference may be found in the fact that the solution of iron in the magnetic field is in a sense equivalent to its withdrawal by mechanical means to an infinite distance. Mechanical removal requires the expenditure of work, and the same thing is doubtless true of what might be called its chemical removal. In other words the number of units of heat produced by the chemical reaction should differ, within and without the field, by an amount equivalent to the work necessary to withdraw the iron to a position of zero potential.

Experiments with aqua-regia and iron show that the speed of reaction is greater in the magnetic field than without and that the heat of chemical union is much greater. Under the influence of the magnet, aqua-regia and iron produce nitrous fumes, whereas when the influence of the magnet is removed only hydrogen is generated.

When experimenting with iron and nitric acid, interesting effects of magnetism on the passivity of the iron were observed; five grams of powdered iron lay in a beaker close above the poles of the electro-magnet which was in circuit. Some cold nitric acid was poured upon the iron, but the latter remained passive. Wishing to note the character of the reaction the author warmed the beaker slightly, then placed it upon the poles of the magnet and put a thermometer into the solution to get its temperature. The bulb of the thermometer touched the iron in stirring the acid, when the hitherto passive mixture burst almost explosively into effervescence, and red nitrous fumes were liberated. Removal of the solution from the field of the magnet restored the pas-

sivity of the iron, and the action in a few seconds ceased entirely. When the beaker was brought back into the neighborhood of the magnet a touch of a glass rod excited again the violent chemical action. Further researches are in progress. (Am. J. Sci. xxxi, 272.)

*Density of Liquid Oxygen and of Liquid Nitrogen*, by S. Wroblewski.—The author finds that liquid oxygen has a density of 0.6 at  $-118^{\circ}\text{C}$ . and of 1.24 at  $-200^{\circ}$  under a pressure of 0.02<sup>m</sup>. The following table gives the constants for liquid nitrogen:

Temperature.	Pressure in atmospheres.	Density referred to water at $4^{\circ}\text{C}$ .	Coefficient of dilatation.
$-146.6$	38.45	0.4552	-----
$-153.7$	30.65	0.5842	0.0311
$-193.0$	1.00	0.83	0.007536
$-202.0$	0.105	0.866	0.004619

Hence the atomic volume of oxygen is less than 14, and that of nitrogen is near 15.5.

The density of liquid air at  $-146.6^{\circ}\text{C}$ . and 45 atmospheres is equal to 0.6. (Comptes Rendus, cii, 1010.)

#### INORGANIC.

##### *Redeterminations of atomic weights.*

Element.	Atomic weight.	Authority.	Reference.
Uranium .....	239.02	Zimmermann .....	Liebig's Annalen, CCXXXII, 299.
Cobalt .....	58.74	do .....	Liebig's Annalen, CCXXXII, 324.
Nickel .....	58.56	do .....	Do.
Platinum .....	194.57	Halberstadt .....	Z. anal. Ch., xxv (ii).
Germanium .....	72.32	Lecoq de Boisbaudran.	Comptes Rendus, cii, 1291.
Antimony .....	120.69	Popper .....	Ann. Chem., CCXXXIII.
Tungsten ( $\sigma = 15.96$ ) ..	184.04	Waddell .....	Am. Chem. J., viii, 280.

*Austrium, a new Element.*—Dr. E. Linnemann, professor of chemistry at Prague, died in April, 1886. Among his papers was found a letter addressed to the Vienna Academy of Sciences, announcing the discovery of a new element, which he called austrium, Aus. Dr. Linnemann obtained the new metal from orthite of Arendal; its spectrum shows two violet lines; the wave lengths were found to be, for Aus.  $\alpha$ ,  $\lambda = 416.5$ , and for Aus.  $\beta$ ,  $\lambda = 403.0$ . Prof. F. Lippich, of Prague, who presented Dr. Linnemann's paper to the Vienna Academy, called attention to the fact that three not yet identified lines ( $\lambda = 415.56$ ,  $\lambda = 416.08$ , and  $\lambda = 416.47$ ) are shown in Ångström's atlas of the normal spectrum of the sun in the neighborhood of the Aus.  $\alpha$  line; the last of them might

be supposed to be coincident with the Aus.  $\alpha$  line ( $\lambda=416.5$ ). (Nature, xxxiv, 59, 1886.)

*Germanium, a new Element*, by Clemens Winkler.—In the summer of 1885 a rich silver ore of uncommon appearance was found in the *Himmelfuerst* mine near Freiberg. It was recognized as a new mineral species by Prof. A. Weisbach, and named by him "argyrodite." Th. Richter subjected the mineral to a preliminary examination with the blow-pipe, and found it to consist essentially of silver and sulphur. In addition to these, he also detected the presence of a small quantity of mercury, which is remarkable and interesting from the fact that this metal had never before been found in the Freiberg ores.

In the analyses made, Winkler found that the mercury did not amount to more than 0.21 per cent. According to the purity of the material the silver varied from 73 to 75 per cent., and the sulphur from 17 to 18 per cent. Small quantities of iron and traces of arsenic were also found. Though the analysis was often and carefully repeated there was always a loss of 6 to 7 per cent. without it being possible by the ordinary methods of qualitative analysis to discover the missing body.

After several weeks of tedious search Winkler found that argyrodite contains a new element, very similar to antimony, but still very distinct from the same, which he named Germanium. The detection of this element was very difficult, because the argyrodite was accompanied by minerals containing arsenic and antimony, which, on account of their similar behavior, and a total lack of a sharp method for separation, caused much difficulty.

Argyrodite, when heated with exclusion of air, preferably in a current of hydrogen, gives a black, crystalline, quite volatile, readily fusible sublimate, which melts to reddish-brown drops. In addition to mercury sulphite it consists essentially of germanium sulphide. Germanium sulphide is a sulpho-acid; it is readily soluble in ammonium sulphide, and when reprecipitated by hydrochloric acid, in a perfectly pure plate, it forms a snow-white precipitate, which is instantly soluble in ammonium hydrate. In the presence of antimony or arsenic the precipitate is always tinged more or less yellow.

On heating in a current of air or in nitric acid, germanium sulphide is converted into a white oxide, which is not volatile at a red heat. It is soluble in potassium hydrate, and the alkaline solution, when acidified with sulphuretted hydrogen, gives the characteristic white precipitate. Too great dilution prevents or retards the precipitation.

The oxide, like the sulphide, is reduced by hydrogen, the latter with greater difficulty on account of its volatility. The element has a gray color, and perfect metallic luster. It melts at a point somewhat below silver, say about  $900^{\circ}$ , and crystallizes in octahedra, which are very brittle. Its specific gravity is 5.469 at  $20^{\circ}$ . It is insoluble in hydrochloric acid, readily dissolved by aqua-regia, is converted into a white



oxide by nitric acid and into a soluble sulphate by concentrated sulphuric acid. Its atomic weight is 72.32, and it proves to be Mendelejeff's *ekasilicium*. It forms two oxides,  $\text{GeO}$  and  $\text{GeO}_2$ , two corresponding sulphides, and two chlorides, both of which are thin colorless fuming liquids. (J. Prakt. Chem., 1886, *passim*.)

*Atomic Weight of Antimony.*—Alfred Popper, of the University of Graz, has made very careful determinations of the atomic weight of antimony, and obtains a mean of 120.69, which is an entire unit more than J. P. Cooke's result, 119.60. He can find no source of error either in Cooke's determinations or in his own, and suggests that the possible presence of germanium may solve the question. (Ann. Chem., CCXXXIII.)

*On some Probable New Elements*, by Alexander Pringle.—The author states that he obtained the material on which he worked from his own landed property, situated upon the river Tweed, county of Selkirk, Scotland. He examined some gravel and other material forming the débris of an ancient glacier, which he "imagines" to be the ancient soil of the very ancient mountains in that geologic formation. He describes more or less fully no less than six probable new elements; *polymnestum* is a metal of rather dark color, with an equivalent of about 74, and forming four oxides of various colors; *erebodium* is as black as charcoal and has an equivalent of 95.4; *gadenium* has an equivalent of 43.6 and forms two oxides; *hesperisium* is a non-metallic element having an equivalent of 45.2, and a red color and a metallic luster like a sunset sky. Two other nameless elements are briefly claimed by the author. (Chem. News, LIV, 167.)

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*Dysprosium, a new Element*, by Lecoq de Boisbaudran.—In October, 1878, Delafontaine announced a new earth, which he called philippium, but early in 1880 he recognized that it was identical with holmium, previously studied by Soret and by Cleve. Later in the same year, however, Delafontaine abandoned this view, because he determined that philippium had no absorption spectra. Lecoq de Boisbaudran has succeeded by several hundred fractional treatments in separating holmium into two bodies, for the first of which he proposes to preserve the name holmium, and the second he names dysprosium ( $\delta\upsilon\sigma\pi\rho\acute{o}\sigma\iota\tau\omicron\varsigma$  = hard to get at). The new holmium has for characteristic absorption bands 640.4 and 536.3, and the bands of dysprosium are 753 and 451.5. The author has encountered extraordinary difficulties in the separation of holmium, erbium, terbium, and dysprosium, and the scarcity of material greatly retards the laborious investigation. (Comptes Rendus, CII, 1003 and 1005.)

*New Elements in Gadolinite and Samarskite detected Spectroscopically*, by William Crookes.—Finding that Lecoq de Boisbaudran is pursuing the spectroscopic study of the rare earths in the same track as himself,

and publishing notes of phenomena already known to Mr. Crookes, the latter gives in this paper a preliminary notice and summary of his studies, although in an unfinished state. Mr. Crookes holds with other chemists the opinion that didymium is not a simple body, but has been unable to split it up into the green praseodymium and rose-red neodymium announced in 1885 by Dr. Auer von Welsbach. Mr. Crookes thinks didymium will prove to be more complex than this indicates.

The author, referring to his note-book under date March 3, 1886, finds the statement that the "big blue line ( $\lambda$  451.5) is still unclaimed," and this blue line proves to be characteristic of dysprosium discovered by Lecoq de Boisbaudran.

As a result of the spectroscopic examination of the fractionated earths from samarskite and from gadolinite the author concludes that the earth hitherto called yttria is a highly complex body, capable of being dissociated into several simpler substances, each of which gives a phosphorescent spectrum of great simplicity, consisting, for the most part, of only one line. The author admits that a hitherto unrecognized band in the spectrum, by absorption or phosphorescence, is not of itself definite proof of a new element, but if supported by chemical facts, such as he details, there is sufficient *prima facie* evidence that a new element is present. Until, however, the new earths are separated in sufficient purity to enable their atomic weights to be approximately determined, and their chemical and physical properties observed, Mr. Crookes thinks it prudent to regard them as elements on probation. He gives in tabular form a list of these probationary elements, designating them by the initial letters of the minerals (or bodies) didymium, samarskite, and gadolinite, from which they are respectively derived, and by the addition to the initials of Greek letters. The table also gives the mean wave lengths of absorption lines in the phosphorescent spectra, and other data.

*Table of Probationary Elements.*

Position of lines in the spectrum.	Scale of spectro-scope.	Mean wave length of line or band.	$\lambda^{\frac{1}{2}}$	Provisional name.	Probability.
Absorption bands in violet and blue .....	} 8.270° 8.828	443	5096	D $\alpha$	New.
Bright lines in—		475	4432	S $\beta$	Do.
Violet .....	8.515	456	4809	S $\gamma$	Ytterbium.
Deep blue .....	8.931	482	4304	G $\alpha$	New.
Greenish blue (mean of a close pair).	9.650	545	3367	G $\beta$	Gadolinite.
Green .....	9.812	564	3144	G $\gamma$	New.
Citron .....	9.890	574	3035	G $\delta$	Do.
Yellow .....	10.050	597	2806	G $\epsilon$	Do.
Orange .....	10.129	609	2693	S $\delta$	Do.
Red .....	10.185	619	2611	G $\zeta$	Do.
Deep red .....	10.338	647	2389	G $\eta$	Do.

Concerning the "radiant-matter test" for these phosphorescing bodies Mr. Crookes says it proves itself every day more and more valuable as one of the most far-searching and trustworthy tools ever placed in the hands of the experimental chemist. It is an exquisitely delicate test, capable of being applied to bodies which have been approximately separated, but not yet completely isolated, by chemical means; its delicacy is unsurpassed even in the region of spectrum analysis; its economy is great inasmuch as the test involves no destruction of the specimen; its convenience is such that any given test is always available for future reference, and the quantity of material is limited solely by the power of the human eye to see the body under examination. Beyond all these in importance is its trustworthiness, and during the five years this test has been in daily use in his laboratory Mr. Crookes has found it well-nigh infallible. Anomalies and apparent contradictions have arisen, but a little more experiment has shown that the anomalies were but finger-posts pointing to fresh paths of discovery, and the contradictions were due to erroneous interpretation of the facts. (Chem. News, LIV, 13.)

*On the Atomic Weight of the Oxide of Gadolinium*, by A. E. Nordenskjöld.—The author signifies by "oxide of gadolinium" the mixture of oxides of yttrium, erbium, and ytterbium first discovered in the gadolinite of Ytterby. He shows that this mixture of three isomorphous oxides, even when derived from totally different minerals found in localities far apart from one another, possesses a constant atomic weight, viz, about 262. The atomic weights of the three constituents vary greatly—

Oxide of yttrium .....	227.2
Oxide of erbium .....	380.
Oxide of ytterbium .....	392.

taking O=16 and calculating as  $R_2O_3$ .

The fact here demonstrated is one altogether new in chemistry and confirms in a remarkable way the views announced by William Crookes in his address to the B. A. A. S. on the genesis of the elements. It would appear that the work of these savants on the rare earths, so called, will result in revolutionizing views of chemists concerning the elements, so called. (Comptes Rendus, CIII, 795.)

*Isolation of Fluorine by Electrolysis of Anhydrous Hydrofluoric Acid*, by H. Moissan.—The preparation of fluorine in its elementary state is a problem which has long defied the efforts of chemists; the classical experiments of Davy, Gore, G. J. Knox, Pfaundler, Baudrimont, and others did not yield results satisfactory to all, and the alleged discovery of Prat was soon after experimentally refuted by Cillis. At the meeting of the French Academy of Sciences, held June 28, Monsieur H. Moissan described the results obtained by electrolyzing anhydrous hydrofluoric acid, and cautiously stated that fluorine was in all probability isolated; this memoir was followed by another on July 19, and soon after by a



third, which finally removed all doubts as to the nature of the gas separated in the experiments.

Moissan prepared anhydrous hydrofluoric acid after the method of Frémy, taking great precautions to eliminate water. This acid was placed in a platinum U-tube, cooled to  $-50^{\circ}$  C. and submitted to the action of an electric current from fifty Bunsen cells. Under these conditions hydrogen was set free at the negative pole, and at the positive pole a gas was obtained in a continuous current and having the following properties: In the presence of mercury it is completely absorbed, with formation of mercury fluoride of a light yellow color; the gas decomposes water, liberating ozone; phosphorus is ignited by it; sulphur is heated, melting rapidly; carbon seems to be without action; melted potassium chloride is attacked with an escape of chlorine; crystalline silicon, purified by treatment with nitric and hydrofluoric acids, takes fire in contact with this gas and burns brilliantly, forming silicon fluoride. The electrode of platin-iridium forming the positive pole is strongly corroded, while that of the negative pole is untouched.

Moissan pointed out that the simplest explanation of these reactions is that they are due to elementary fluorine, but he deferred decision until he could show that the phenomena were not due to hydrogen perfluoride or to a mixture of ozone and hydrofluoric acid.

In the second memoir Moissan details the precautions observed in preparing the anhydrous hydrofluoric acid and gives additional data concerning the behavior of the gas. The anhydrous acid is made by heating to redness in a platinum vessel very carefully dried double fluoride of potassium and hydrogen (HF KF), the liquid being condensed in a receiver cooled with a mixture of ice and salt. The anhydrous acid boils at  $19^{\circ}.5$ , is very hygroscopic, and fumes abundantly in moist air. For electrolysis the acid was cooled with chloride of methyl to  $-23^{\circ}$ , and a current of twenty Bunsen cells sufficed. Absolutely anhydrous hydrofluoric acid will not conduct electricity, therefore a small quantity of fused double fluoride of potassium and hydrogen is added.

The gas liberated at the positive pole not only attacks silicon in the cold, but adamantine boron as well.

Sulphur takes fire in the gas, as do arsenic and antimony. The metals are attacked with less energy; organic bodies, however, are violently attacked; alcohol, ether, benzene, petroleum, etc., take fire on contact.

When the experiment has lasted several hours and the gases are no longer separated by liquid hydrofluoric acid in the bend of the tube, the gases H and F recombine in the cold with violent detonation.

In the third memoir the author shows that the same gas can be obtained by the electrolysis of carefully dried and fused double fluoride of hydrogen and potassium. The temperature maintained is  $110^{\circ}$ . He also describes experiments showing conclusively that the gas in question is free fluorine; under certain conditions the gas was absorbed



by a weighed amount of iron, and a weight of iron fluoride was obtained sensibly corresponding to the weight of the hydrogen liberated.

The isolation of fluorine by M. Moissan was regarded by the French Academy of Sciences as of such prime importance that the subject was referred to a committee for examination. This committee reported through its chairman, M. Debray (on the 8th of November), that they found Moissan's experiments and statements satisfactory in all respects, and that the isolation of the element was undoubtedly an accomplished fact. (*Comptes Rendus*, CII, 1543, CIII, 202, 256, and 850.)

*A New Gaseous Body, Phosphorus Oxyfluoride*, by H. Moissan.—The new compound  $\text{PF}_3\text{O}_2$  has an experimental density, which oscillates between 3.68 and 3.75. It is instantly absorbed by anhydrous alcohol, by solutions of chromic acid, or by the alkalis. The existence of this compound renders impossible the experiment indicated by Davy, who proposed to isolate fluorine by burning phosphorus fluoride in an atmosphere of oxygen inclosed in a vessel of fluor-spar. Fluorine has the curious property of tending always to form ternary or quaternary addition products. (*Comptes Rendus*, CII, May 31, 1886.)

*The Combustion of Carbonic Oxide and Hydrogen*, by Harold B. Dixon.—The author in 1880 published the fact that a mixture of carefully dried carbonic oxide and oxygen would not explode when electric sparks were passed through it, but that by the addition of a minute trace of water or volatile body containing hydrogen the mixture became inflammable. To account for this fact the author has more recently put forward the hypothesis that the steam acts as the part of a carrier of oxygen, and that it undergoes reduction and successive re-formation. Discussion has arisen\* as to the mode in which steam exerts its influence, and the author herein gives his reasons for maintaining his hypothesis.

Experiments were made with small quantities of various gases added to the non-inflammable mixture of dry carbon monoxide and oxygen, and the electric spark passed. In all cases where a gas containing hydrogen was introduced the mixture exploded; otherwise, not. Steam, therefore, and bodies which form steam under the conditions of the experiment, are alone able to determine the explosion, and it is evident that steam does not act as a mere third body, but in virtue of its own peculiar chemical properties.

Moritz Traube rejected Mr. Dixon's explanation of the phenomena under consideration, claiming that carbon monoxide does not decompose steam at high temperatures, but the author shows that it has been amply proved by different experiments, notably by Naumann and Pistor (*Berichte d. chem. Ges.*, 1885, 2894) that the re-action mentioned does take place. Mr. Dixon also gives experimental data for refuting Traube's view that hydrogen peroxide acts as the carrier of oxygen.

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\* See Report on Chemistry in Smithsonian Report for 1885, p. 651.

In a note following Mr. Dixon's paper, Professor Armstrong suggests that in a mixture of carbon monoxide and oxygen, the former is oxidized and the latter hydrogenized simultaneously by the steam present, a view which Mr. Dixon remarks is not opposed to any of the observed facts. The explanation offered by Professor Armstrong involves the simultaneous occurrence of two re-actions, which Mr. Dixon regards as taking place successively. (J. Chem. Soc. [London], 1886, 94.)

*On the Combustion of Cyanogen*, by Harold B. Dixon.—The author has examined the conditions under which a mixture of cyanogen and oxygen gases explodes, and comes to the conclusion that the explosion depends solely upon the nature of the spark itself. The spark from a Holtz machine failed entirely to explode dry mixtures of these gases. The induction spark failed to explode the mixture in the eudiometer, where the wires were 0.25 to 1<sup>mm</sup> apart; but the explosion was violent in the tubes when the wires were 1 to 3<sup>mm</sup> apart, and this was the case where the gases were moist. He then compared the explosion rate of this mixture with that of carbon monoxide and oxygen, using for the purpose a tube 10 feet long and recording the time on a pendulum chronograph. The velocities obtained were as follows in meters per second: Cyanogen and oxygen, dried with phosphoric anhydride, 813; dried with KHO, 808; saturated with moisture at 15° C., 752. Carbon monoxide and oxygen dried with phosphoric anhydride, 36; dried with H<sub>2</sub>SO<sub>4</sub>, 119; saturated with moisture at 10° C., 175; at 35° C., 244; and at 60°, 317. It is notable that in the latter case the rate of explosion increases rapidly by the addition of moisture, while with the cyanogen moisture produces an opposite effect. When a platinum wire is heated to dull redness in the mixture of cyanogen and oxygen, the coil cooled without result when the circuit was opened; but when raised to full redness it glowed brightly for half a minute after the current was broken, and orange fumes appeared in the tube. On opening the tube it was found that about three-fourths of the cyanogen had been converted into carbon dioxide, and one-fourth into carbon monoxide. (J. Chem. Soc., XLIX, 384.)

*Preparation of Hydrogen Dioxide*, by James Kennedy.—The author points out the difficulty of removing the barium chloride by means of silver sulphate when preparing hydrogen dioxide by Regnault's method, and the uncertainties of Fownes's method, and proposes the following, for which he claims simplicity and economy.

Place any convenient quantity of tribasic phosphoric acid in a shallow porcelain vessel immersed in a freezing mixture (ice and salt), and when the temperature has fallen to 40° F. or below, saturate with peroxide of barium previously made into moderately thick paste with distilled water; when completely saturated filter through pure filter paper.

Certain precautions are to be observed in this process in order to in-

sure success. The use of a shallow vessel to allow a large contact surface with the freezing mixture; the  $\text{BaO}_2$  must be added very slowly to prevent too great a rise in temperature, and stirred constantly. The  $\text{BaO}_2$  should be added until the mixture shows a slight alkaline reaction to insure the complete precipitation of  $\text{BaHPO}_4$ , as this compound is soluble in acids. The solution is freed from dissolved barium by addition of diluted sulphuric acid, and the insoluble precipitate removed by filtration.

In order to prevent the decomposition of the  $\text{H}_2\text{O}_2$ , the temperature should not be allowed to rise above  $40^\circ$  or  $45^\circ$  F. The reaction in this process is explained in the following equation:  $\text{BaO}_2 + \text{H}_3\text{PO}_4 = \text{BaHPO}_4 + \text{H}_2\text{O}_2$ .

The solution obtained is sufficiently concentrated for most purposes to which it is applied, and is much stronger than much of that found in commerce. (Pharm. News, VI, 148.)

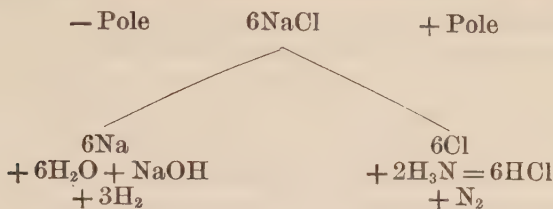
*Hydrogen Peroxide and its Estimation*, by Maurice de Thierry.—Since its discovery by Thénard in 1818, hydrogen peroxide has remained a mere chemical curiosity, but it has recently acquired industrial importance. It is now used not only for restoring blackened oil paintings, but a large quantity is consumed in bleaching ostrich feathers, silk, and hair. When pure, peroxide of hydrogen has a density of 1.454, but the commercial product is much weaker; its activity being dependent on its concentration the author has devised a method for determining the value of samples. The method is based on the decomposition by manganese dioxide and is conveniently carried out by means of the simple apparatus figured in the original memoir. (Comptes Rendus, CII, 611.)

*Hydrates of Sulphuric Acid*.—At the January meeting of the Russian Chemical Society Professor Mendelejeff communicated some results of his investigations into the thermic effects of dilution of sulphuric acid with water. The maximum evolution of heat, and the maximum contraction of 100 parts of the solution both correspond to the solution containing from 65 to 75 per cent. of  $\text{H}_2\text{SO}_4$ , which is very near the hydrate  $\text{H}_6\text{SO}_6 = \text{S}(\text{OH})_6$ . Together with some other observations this leads the author to the conclusion that there exist at least five more or less constant hydrates of sulphuric acid, viz,  $\text{H}_2\text{SO}_4$ ,  $\text{H}_4\text{SO}_5$ ,  $\text{H}_6\text{SO}_6$ , and two more containing a large amount of water, as  $\text{H}_2\text{SO}_4 + 100 \text{ H}_2\text{O}$ . (Nature, xxxiii, 591.)

*Decomposition of Ammonia by Electrolysis*, by the Rev. A. Irving.—The author electrolyzes a concentrated solution of sodium chloride, with which is mixed about one-tenth its volume of the strongest solution of ammonia. The solution is placed in an ordinary three-tubed voltameter of Hofmann's form, into which carbon pencils are introduced (with the aid of corks), to obviate the action of nascent chlorine on platinum were this metal used for the electrodes. With four to six Bunsen



or Grove cells a considerable volume of nitrogen and hydrogen is liberated in the separate tubes in a few minutes. The re-action may be thus represented :



The HCl is of course fixed by the free ammonia. The experiment is suitable for the lecture table. (Chem. News, LIV, 16.)

*Electrolytic Aluminium.*—L. Senet has devised a new process for obtaining aluminium, as well as copper, silver, etc., by electrolysis. He exposes a saturated solution of sulphate of alumina, separated from a solution of chloride of sodium by a porous vessel, to a current of 6 or 7 volts and 4 ampères. The double chloride of aluminium and sodium is decomposed, and the aluminium is deposited upon the negative electrode. (Cosmos, August 10, 1885.)

*Researches on Titanium and its Compounds*, by Otto Freiherr von der Pfordten—First Part.—The results of this lengthy investigation are thus summarized by the author :

(1) Pure sulphuretted hydrogen can be prepared by drying the gas over phosphorus pentoxide and passing it through chromous chloride, which removes the oxygen.

(2) The hydrogen evolved in the usual way by zinc and acid contains no oxygen.

(3) With titanium and some other elements having a great affinity for oxygen the sulphides can best be obtained by the action of sulphuretted hydrogen on the chloride. The action of sulphuretted hydrogen on the oxide does not give pure products.

(4) At a low temperature sulphuretted hydrogen reduces tetrachloride of titanium to the dichloride, and at a higher temperature another compound forms, probably a sulpho-chloride.

(5) On the other hand, at a red heat, a pure crystalline disulphide is obtained, derived from the product first formed.

(6) Disulphide of titanium is oxidized by carbonic acid gas free from oxygen. (The only known case of a metallic sulphide decomposing carbon dioxide.)

(7) Disulphide of titanium in nitrogen is changed to sesquisulphide. Hydrogen effects the same at a high heat in glass.

(8) The same is reduced by hydrogen in a highly-heated platinum tube to monosulphide.



(9) The properties of the three sulphides are fully described and compared. (Am. Chem., CCXXXIV, 257.)

*Occurrence of Titanium in Eruptive Rocks and Clays.*—The work done in the division of chemistry and physics of the U. S. Geological Survey during the year 1884-'85 forms Bulletin No. 27 of the series issued by the Survey. The chemical papers include one on topaz from Stoneham, Maine, by F. W. Clarke, the chief chemist, a method of separating titanium and aluminium, by F. A. Gooch, a method of filtration, by the same author, and a number of miscellaneous analyses of minerals, rocks, soils, ores, and water. Analyses of several eruptive rocks and of clays show a considerable percentage of titanium:

Rock.	Per cent. TiO <sub>2</sub> .
Hornblende-andesite, from Hagne Volcano, Bogosloff Island, Alaska . . . . .	1.24
Eruptive rock from New Mexico . . . . .	0.92
Another specimen from New Mexico . . . . .	2.67
Basalt, from New Mexico . . . . .	2.76
Clay, Henry County, Illinois . . . . .	0.79
Another sample from Illinois . . . . .	0.64
Clay from Dodgeville, Wisconsin . . . . .	0.45

*A New Oxide of Zirconium and its Utility in the Determination of this Element,*—Bailey.—By the action of hydrogen peroxide on zirconium sulphate the author obtained a white bulky precipitate, which proved to have the formula  $Zr_2O_5$ . This is a perfectly stable and definite body, less readily soluble in dilute sulphuric acid than  $ZrO_2$ , and of positive utility in analytical determinations. Hydrogen peroxide does not precipitate iron, aluminium, titanium, niobium, tantalum, tin, nor silicon, and the zirconium can be separated from all or any of these. With a moderately concentrated solution of hydrogen peroxide the precipitation is complete. (J. Chem. Soc., XLIX, 149.)

*Researches on Uranium,* by Clemens Zimmermann; Third Paper, published after the author's death by George Alibegoff and Gerhard Krüss.—A careful examination of the reactions of the oxide of uranium,  $U_3O_8$ , has led the author to the conclusion that the oxide  $U_2O_5$  of Péligot is a mixture, and that a body having this composition does not exist. Péligot's results were based on the behavior of  $U_3O_8$  when ignited in the air. Zimmermann finds that  $U_3O_8$  ignited in the air loses varying quantities of oxygen, but if ignited in an indifferent gas, like N or  $CO_2$ , the uranic oxide is gradually and completely converted into  $UO_2$ .  $U_3O_8$  is only absolutely stable when ignited in a current of oxygen. The color of the  $U_3O_8$  varies with the method of preparation, and therefore can not be used to control its purity.

Determinations of the atomic weight of the element, conducted in several ways, lead to the value 239.02. (*Ann. Chem.*, CCXXXII, 273.)

*New Compounds of Vanadium*, by J. T. Brierley.—By mixing a blue solution of hypovanadium sulphate with a colorless one of an alkaline metavanadate the author has obtained the following series of new compounds:

A soluble sodium salt,  $2V_2O_4, V_2O_5, 2Na_2O + 13H_2O$ .

A soluble potassium salt,  $2V_2O_4, V_2O_5, 2K_2O + 6H_2O$ .

An insoluble potassium salt,  $2V_2O_4, 4V_2O_5, 5K_2O + H_2O$ .

A soluble ammonium salt,  $2V_2O_4, 2V_2O_5, (NH_4)_2O + 14H_2O$ .

An insoluble ammonium salt,  $2V_2O_4, 4V_2O_5, 3(NH_4)_2O + 6H_2O$ .

The first named crystallizes well in hexagonal plates of considerable size, and black color. The last named is a precipitate insoluble in hot water. (*Ann. Chem.*, CCXXXII, 359.)

*Non-existence of Silver Subchloride*, by Spencer B. Newbury.—The author has obtained the product called silver subchloride ( $Ag_2Cl?$ ) by the three methods of Cavillier, Wetzlar, and Wöhler, and after careful examination and analysis, finds that there is no evidence whatever of the existence of such a compound, and believes the substances supposed to be silver subchloride are nothing but simple mixtures of silver and silver chloride. He also rejects the existence of the silver subcitrate obtained by Wöhler and von Bibra, claiming that the loss of weight on heating silver citrate in hydrogen, the formation of carbon dioxide, and residue of metallic silver indicate the decomposition of citric acid and separation of silver rather than the formation of silver subcitrate. (*Am. Chem. J.*, VIII, 196.)

*On Berthollet's Fulminating Silver*, by F. Raschig.—Although this substance was discovered by Berthollet nearly one hundred years ago, it has not been since closely studied, and its constitution has been uncertain. Berthollet obtained it by the action of ammonia on silver oxide. Raschig prepares it as follows: A solution of silver nitrate is precipitated with sodium hydroxide, and the silver oxide is washed by decantation in the beaker and then transferred to a small flask. For each gram of silver nitrate used 2 c. c. of an ammonia solution, containing 25 per cent. of  $NH_3$ , is added to the oxide, which dissolves easily with very slight residue. The solution of fulminating silver thus obtained is divided into several portions, and each dish is covered with a watch glass and allowed to stand sixteen to twenty hours. The ammonia evaporates, leaving the fulminating silver as a black crystalline mass. After washing it was analyzed by digesting with very dilute sulphuric acid, which usually leaves a residue of metallic silver. The dissolved silver was precipitated with hydrochloric acid, and the ammonia determined in the filtrate as platinic chloride. The results

of sixteen analyses gave ratios approximating three atoms of silver to one of nitrogen, which gives the formula  $\text{NAg}_3$ .

The substance was also prepared by warming the ammonia solution of the silver oxide on a water bath, and by precipitating it with alcohol, and these samples gave the same results on analysis. Berthollet's fulminating silver explodes with a very slight concussion when dry, and even when moist must be handled with precaution. The explosive character of each sample analyzed was determined. It dissolves in potassium cyanide solution almost immediately, probably giving the reaction:



(Liebig's *Annalen*, CCXXXIII, 93.)

*Compounds of the Nitrates of the Alkalies with Nitrate of Silver*, by A. Ditte.—The author describes the preparation and characteristics of the following double salts:  $\text{AgNO}_3$ ,  $\text{KNO}_3$ ;  $\text{AgNO}_3$ ,  $\text{RbNO}_3$ ;  $\text{NH}_4\text{NO}_3$ ,  $\text{AgNO}_3$ ; and shows that with sodium and lithium analogous double salts are difficult to obtain in definite compounds. No less than twelve reasons are presented for dividing the alkaline group of metals into two sections, one embracing K, Rb, Cs,  $\text{NH}_4$ ; and the other, Li and Na. (*Ann. Chim. Phys.* [6], VIII, 418.)

*Decomposition of Potassium Chlorate*, by Frank L. Teed.—In a previous paper the author arrived at the conclusion that the decomposition of potassium chlorate by heat was represented by the equation:



but later experiments lead him to believe that the following is more nearly correct:



A majority of the author's results fall within the limits calculated from these two equations. When the chlorate is heated with manganese dioxide it decomposes apparently without formation of perchlorate.

In the discussion which followed the reading of this paper at the Chemical Society of London, Dr. Percy Frankland said experiments made in the South Kensington laboratory had lead to the equation:



(*Chem. News*, LIII, 56.)

For a further discussion of this subject see article by E. J. Maumené in *Chem. News*, LIII, 145.

*The Solvay Process of Manufacturing "Soda."*—In our reports for 1883 and 1884 we chronicled the decline of the Leblanc process and the rise of the so-called "ammonia process" of manufacturing soda; we now

note the establishment of a manufactory of carbonate of soda by the latter process in the United States.

Solvay & Co. have established extensive works for conducting the process with which their name is connected in Belgium, France, Germany, Russia, and Austria; and a company of gentlemen, which has secured the right to work under all the Solvay patents, has erected works at Geddes, near Syracuse, New York State. These works produced in 1885 14,651,500 kilos. of 98 per cent. carbonate of soda, and the production for 1886, with increased facilities, is estimated to reach 30,000,000 kilos.

The purity of the product is shown by the following analysis of the brand known as "Pure Soda:"

<i>Analysis of "Pure Soda."</i>	
	Per cent.
Iron and aluminum oxides.....	.025
Silica.....	.025
Carbonate of lime.....	.404
Carbonate of magnesia.....	.175
Chloride of sodium.....	.904
Carbonate of soda.....	93.730
	<hr/> 100.263

This product, being very pure, is especially adapted for glass making, soap making, paper making, scouring textile fabrics, and all the innumerable uses to which this adjunct of civilization is continually put.

The product of all the works making soda under the Solvay patents is over 220,000 tons per annum, and new establishments are rising in several localities.

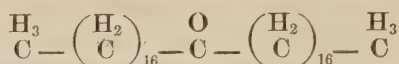
*Composition of a Crystalline Scale formed in the Ammonia-Soda Process*, by George W. Leighton.—The crystalline scale, formed on the inner surface of an iron tank, in which vapors consisting of ammonia, carbon dioxide, and small quantities of hydrogen sulphide are passed through brine holding in solution the chlorides of sodium, magnesium, and calcium, with a small amount of calcium sulphate, has been examined. It has the appearance of a boiler scale, from one to two inches thick, with a vitreous luster and greenish-gray color, although sometimes black on the surface. The scale is usually covered with crystal planes, which prove to be the terminations of prisms (probably monoclinic). Analysis gave results corresponding closely to the formula:  $\text{MgC}_2\text{O}_4$ ,  $\text{Na}_2\text{CO}_3$ ,  $\text{NaCl}$ ; and impurities consisting chiefly of  $\text{CaCO}_3$ . This is not a mixture, but an interesting triple salt analogous to some mineral species. (Proc. Am. Acad. Arts and Sci., XXII, 158.)

#### ORGANIC CHEMISTRY.

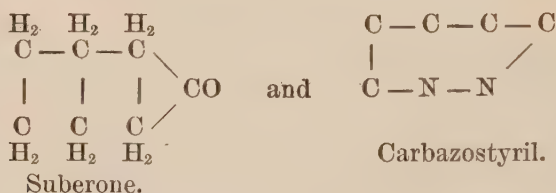
*On the Formation of So called closed Chains*, by Prof. Victor Meyer.—Carbon atoms possess the marked peculiarity of combining to form molecules in so-called chains, a property giving rise to the multiplicity



of organic bodies. In stearone no less than thirty-five carbon atoms unite to form a chain, which may be indicated thus :

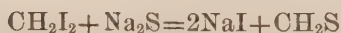


A limit to the extent of open-chain structure can not be predicted, but the case is very different when closed chains are considered. While closed chains of three, four, five, and six links or atoms are numerous, the problem of forming rings having a greater number of links has been scarcely attacked by chemists. If bodies like anthracene and acridine, having double rings of the benzene type, be excepted, only two substances are known having seven links in the molecular ring. These are :

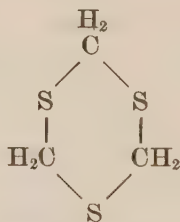


The author has begun the study of the construction of rings having a number of links greater than six, and some of the results are as follows :

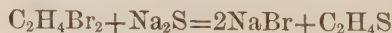
Sodium sulphide acts on iodide of methylene in accordance with the equation :



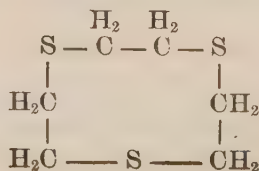
But A. W. Hofmann has shown that the molecular weight of  $\text{CH}_2\text{S}$  is three times as great as thus indicated, and Meyer formulates this as follows:  $\text{C}_3\text{H}_6\text{S}_3$  or



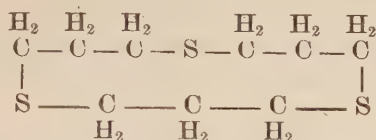
By a study of the body formed in the re-action



the author arrives at the conclusion it should be formulated thus :



which is an example of a closed chain of nine links. Further researches led the author to the discovery of a body having the following constitution:



which is the first example of a closed chain of twelve links. These bodies are quite unstable, as indeed might be anticipated from their complex structure. (Naturwiss. Rundschau, I, 2, 1886.)

*Products of the Manufacture of Gas from Petroleum*, by Henry E. Armstrong and A. K. Miller.—This paper gives results of an investigation which the authors have conducted during several years, on the decomposition and genesis of hydrocarbons at high temperatures; their main object has been to throw light on the nature of the changes resulting from the decomposition of petroleum hydrocarbons at high temperatures. The authors have thus far recognized among the products of the manufacture of oil-gas the following hydrocarbons:

- (a) Paraffines, only in traces.
- (b) Pseudolefines, or saturated hydrocarbons of the series  $\text{C}_n\text{H}_{2n}$ , such as occur in Russian petroleum; present in relatively small amount.
- (c) Olefines, viz, ethylene, propylene, normal amylene, hexylene, and heptylene; higher homologues being absent.
- (d) Pseudacetylenes, viz, crotonylene (dimethylenethane) and isopropylene.
- (e) Benzenoid hydrocarbons, viz, benzene, toluene, the three isomeric dimethylbenzenes, the two trimethylbenzenes (pseudocumene and mesitylene), and naphthalene. (J. Chem. Soc. [London], 1886, p. 74.)

*Some Organic Substances of High Refractive Power*, by H. G. Madan.—The author finds that naphthyl-phenyl-ketone has a refractive index of 1.666, which is even higher than that of carbon disulphide (1.63). Its dispersive power is almost exactly that of carbon disulphide.

Metacinnamene has a refractive index of 1.593; monobromonaphthalene has a refractive index of 1.662, and the author thinks it may prove a valuable substitute for carbon disulphide for filling prisms, as it is much less volatile and inflammable. Mr. Madan mentions as a great desideratum a substance having all the excellent qualities of Canada balsam—colorless, neutral, permanent in the air, becoming fluid when moderately heated, but hard and tough when cold, and with a refractive index of at least 1.66. Such a substance would be invaluable for mounting microscopic objects. (Phil. Mag. [5], XXI, 245.)

*A Convenient Method of Preparing Organic Compounds of Fluorine*, by O. Wallach.—The author finds that organic bodies containing fluorine

can be readily obtained by the action of aqueous hydrofluoric acid on diazoamido compounds. He describes fluorbenzene ( $C_6H_5Fl$ ) boiling at  $84^\circ$  to  $85^\circ$ , parafluortoluene boiling at  $116^\circ$  to  $117^\circ$ , fluornitrobenzene, fluoranilin, and other bodies. It appears that the replacement of hydrogen by fluorine changes very little the boiling points of the bodies, but greatly increases their specific gravities. (Ann. Chem., ccxxxv, 255.)

*On Platoso-Oxalic Acid*, by H. G. Söderbaum.—Doebereiner formerly obtained, by the action of oxalic acid upon the sodium salt of platinum dioxide, a salt of a copper-red color, which he regarded as platinous oxalate. Souhay and Lenssen assign it the formula  $PtNa_2C_4O_8 + 4H_2O$ . This salt has much analogy with the platinum sulphites, since the solution gives neither the reactions of platinum nor those of oxalic acid. We may therefore regard this compound as the sodium salt of platoso-oxalic acid, which has been isolated.

The salts of platoso-oxalic acid are very remarkable, because they occur in isomeric or rather polymeric forms.

For the preparation of the sodium salt sodium chloro-platinate is heated with an equal weight of sodium hydrate. The residue is treated with water, which dissolves out sodium chloride, leaving a yellow powder,  $Na_2O, 3PtO_2, 6H_2O$ . More of it is obtained by the addition of hydrochloric acid to the solution of sodium chloride, avoiding excess. It is washed with cold water and washed with one and a half parts of crystalline oxalic acid. Carbonic acid escapes, and there is obtained a solution of an intense blue color, from which cold slender brown needles of a metallic luster are deposited. This salt is collected upon a filter and repeatedly washed with boiling water. There filters first a yellow solution, then a greenish or blue one, and lastly a solution of a reddish-brown. From the last liquid the mass of the sodium salt is deposited on cooling, crystallized in capillary needles of a coppery luster. The first solution after some time deposits lemon-yellow prisms of an isomeric salt. The intermediate solutions deposit mixtures of the two salts. Both salts yield with silver nitrate a yellowish-white precipitate of microscopic crystals of the silver salt of platoso-oxalic acid. On decomposing this silver salt with the calculated proportion of hydrochloric acid we obtain an indigo-blue solution, containing platoso-oxalic acid. We may obtain the salts of the acid either by the double decomposition of the sodium salts or by neutralizing the free acid with bases or carbonates. With the brown sodium salt there are obtained salts of a brown, greenish, or blue color; but with the yellow salt we obtain isomeric yellow or orange salts. The free acid generally gives salts of the former class, *i. e.*, of a dark color, but by repeated crystallizations yellow salts may be obtained. Several metals belonging to the zinc group form dark-colored salts most readily; others, for instance silver, yield yellow salts, and others again form with equal ease either dark or yellow salts. The tri- and tetra-atomic metals give both dark and yellow salts, but of

a different composition. The dark salts are in general less soluble; their density is lower and they often contain a smaller number of molecules of crystalline water. The difference between the two classes of salts does not depend on the water of crystallization, because both dark and yellow anhydrous salts have been obtained, and because there exist both yellow and dark salts containing the same number of molecules of crystalline water.

The salts of platoso-oxalic acid are in general sparingly soluble in cold dilute acids; they are insoluble in alcohol. In hot water some of them dissolve readily; others are sparingly soluble. Most of them contain crystalline water, which they lose in part or entirely at  $100^{\circ}$ . They bear the temperature of  $110^{\circ}$  to  $115^{\circ}$  (though the ammonium salt is decomposed at  $100^{\circ}$ ); but a little above this temperature they begin to decompose. If suddenly heated they are decomposed with detonation.

Platoso-oxalic acid,  $\text{PtC}_4\text{O}_8\text{H}_2 + 2\text{H}_2\text{O}$ , the preparation of which has been described above, gives, when its solution has been evaporated in a vacuum, a red crystalline mass of a metallic luster. It dissolves readily in water with an indigo-blue color, but this color changes to yellow on heating or diluting with water. Yet the blue color returns on cooling or on concentration.

There are two potassium salts, a brown one forming copper-colored needles of specific gravity 3.01, and a yellow one in hexagonal prisms of specific gravity 3.03. Both contain the same number of molecules of crystalline water. With the ammonium salts the case is similar. The dark sodium salt forms slender needles containing 4 molecules of crystalline water, whilst the yellow salt forms prisms with 5 molecules of crystalline water. There are three isomeric calcium salts: the brown one, with  $6\frac{1}{2}\text{H}_2\text{O}$ ; the  $\beta$ -yellow salt, with  $4\text{H}_2\text{O}$ , losing one molecule water at  $100^{\circ}$ ; and the  $\gamma$ -yellow salt, with  $8\text{H}_2\text{O}$ , losing at  $100^{\circ}$   $5\text{H}_2\text{O}$ . There are also three strontium salts:  $\alpha$ , dark, contains  $3\frac{1}{2}\text{H}_2\text{O}$  and loses  $\frac{1}{2}\text{H}_2\text{O}$  at  $100^{\circ}$ ;  $\beta$ , also dark, contains  $6\frac{1}{2}\text{H}_2\text{O}$ , and loses  $3\text{H}_2\text{O}$  at  $100^{\circ}$ ; and  $\gamma$ , yellow, contains only 3 molecules of crystalline water and undergoes no change at  $100^{\circ}$ .

These researches were made in the laboratory of Prof. P. T. Clève. (Bull. Soc. Chim., 1886, 188.)

*Iodo-aldehyde* is obtained by P. Chautard by acting on an aqueous solution of aldehyde with a mixture of iodic acid and iodine.



Iodo-aldehyde forms an oily, volatile, non-inflammable, colorless, limpid liquid, blackening rapidly on exposure to light. It decomposes at  $80^{\circ}\text{C}$ ., but in solution may be heated to high temperatures without change. It acts as a strong caustic, attacking eyes and respiratory organs. Its density is 2.14 at  $20^{\circ}$ . It is soluble in all proportions in alcohol, ether, benzene, chloroform, etc. It combines readily with aniline and other ammonia derivatives. (Comptes Rendus, cii, 118.)



*Synthesis of Conine*, by A. Ladenburg.—Conine, the volatile alkaloid which forms the poisonous principle of hemlock (*conium maculatum*), was discovered in 1827 by Giesecke, but was first obtained in a pure state in 1831 by Geiger. It has been often studied by chemists, notably by Ortigosa, Blyth, Wertheim, and Kekulé and von Planta; the two latter gave it the formula  $C_8H_{15}N$ , but it is now known to be  $C_8H_{17}N$ . It forms a colorless, oily liquid of pungent odor, specific gravity = 0.89; boiling point  $166^\circ$  to  $168^\circ$ . It is easily soluble in alcohol and ether, sparingly in water, and forms crystalline deliquescent salts. It is an active poison. This natural alkaloid has been formed synthetically by Ladenburg in the manner to be described. Hugo Schiff, in 1871, thought he had effected this synthesis by the action of alcoholic ammonia on normal butyric aldehyde and subjecting the product to dry distillation, but the base thus obtained proved to be paraconine, an isomeric form.

Ladenburg's researches on the pyridine bases had already yielded him interesting results. The synthesis of piperidine was noted in our report for the year 1884. On the 25th of February he read a paper before the German Chemical Society entitled "Experiments on the Synthesis of Conine," in which he announced the preparation of a base very closely resembling this alkaloid, and in October he presented details of this remarkably interesting synthesis, and proofs of the identity of the artificial and natural substances. The process is as follows: Paraldehyde and  $\alpha$ -picoline are heated for ten hours in closed tubes to a temperature of  $250^\circ$  to  $260^\circ$ . The allylpyridine thus obtained was separated from the unchanged picoline, purified and fractioned until it distilled at  $187^\circ.5$  to  $192^\circ.5$ . The exact nature of this body was carefully established by many tests. The  $\alpha$  allylpyridine was then submitted in alcoholic solution to the reducing action of sodium, whereby  $\alpha$ -propylpiperidine was obtained. The hydrochloride of this base, when purified, melted at  $203^\circ$  to  $205^\circ$ , and crystallized in silky-white needles.

The base separated from this salt boiled at  $166^\circ$  to  $167^\circ$  and proved to have the greatest resemblance to conine. After a very careful study of its toxic and optical properties the author satisfied himself of the absolute identity of this dextro- $\alpha$ -propylpiperidine and conine,  $C_3H_7 \cdot C_5H_{10} \cdot HN$ . (Ber. d. chem. Ges., XIX, 439 and 2578.)

*New Synthesis of an Inactive Borneol*, by J. Bouchardat and J. Lafont.—Berthelot accomplished the synthesis of the camphor of Borneo by treating camphor with potassium alcoholate, and Baubigny by the direct addition of hydrogen. The authors effect the transformation of terebene, or inactive camphene,  $C_{10}H_{16}$ , through the medium of an organic acid into an ether of borneol, which by saponification yields a borneol having no influence on polarized light. With the exception of its inactive optical properties, the new body is identical with borneol. (Comptes Rendus, CII, 171.)

*Synthesis of Ammonium Cyanide by Electricity*, by A. Figuier.—By passing a current of silent electricity through a mixture of one volume of methane and two volumes of nitrogen, cyanide of ammonium is formed and noticeable by its odor.



The product was collected and its identity established. (*Comptes Rendus*, CII, 694.)

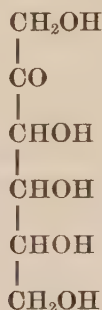
*Synthesis of Mellitic Acid and of other Benzo-carbonic Acids by Electrolyzing Water with Carbon Electrodes*, by A. Bartoli and G. Papasogli.—By the electrolysis of distilled water with electrodes of pure carbon and a battery having an electromotive force equal to 1,200 Daniells, the authors obtained a black insoluble deposit (mellogen) and a very acid liquid which was found to contain mellitic, pyromellitic, hydromellitic, and hydropyromellitic acids. During the electrolysis carbon monoxide and dioxide with very little oxygen were evolved. Mellogen purified by precipitation from the aqueous solution by hydrochloric acid forms an amorphous, neutral, black, and friable body, insoluble in alcohols and soluble in water, to which it imparts an intensely black color. Mellogen dried at  $140^\circ$  has the composition  $\text{C}_{11}\text{H}_2\text{O}_4$ , and has some analogy with Brodie's graphitic acid  $\text{C}_{11}\text{H}_4\text{O}_5$ , but the two bodies are not identical. Oxidizing agents convert it into benzo-carbonic acids. (*Annales Chim. Phys.* [6], VII, 349 and 364.)

*Products of the Electrolysis of a Solution of Ammonia with Coke Electrodes*, by A. Millot.—A solution of ammonia containing 50 per cent. was electrolyzed with electrodes of coke purified by chlorine, and the chief products are an azulmic matter (which the author is still studying), urea, ammelide, biuret, and guanidine. The urea and guanidine probably arise from action of nascent carbon dioxide on ammonia with elimination of water. Biuret is probably formed by the action of carbon dioxide on guanidine, and ammelide from the action of this gas upon biuret with the co-operation of urea. Cyanuric acid was sought but not found. These results differ from those of Bartoli and Papasogli, who added salt to the ammoniacal solution to render it a better conductor, and the nascent chlorine resulting destroyed the above-mentioned products. (*Comptes Rendus*, CIII, 153.)

*Identity of Cadaverine with Pentamethyldiamine*, by A. Ladenburg.—Brieger in the course of his remarkable researches on ptomaines isolated from a cadaver a base having the formula  $\text{C}_5\text{H}_{14}\text{N}_2$ , and which he named cadaverine. This base was also discovered in decomposing fish. Brieger, noting the resemblance in properties between cadaverine and pentamethyldiamine, sent a small specimen of the former to Ladenburg for investigation. The latter chemist found the reactions of the two bodies similar in all respects except in their behavior with mercuric

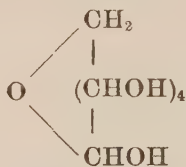
chloride; but he succeeded in transforming cadaverine into piperidine by a known process and thus fully established the identity of the two bodies. (Ber. d. chem. Ges., XIX, 2585.)

*On the Constitution of Levulose and Dextrose*, by Heinrich Kiliani.—According to the author, levulose is a ketone alcohol, and has the constitution



This result was arrived at by studying the behavior of levulose with hydrocyanic acid.

The question whether dextrose is an aldehyde or an anhydride is not entirely settled, but the probable constitution is



(Ber. d. chem. Ges., XIX, 767 and 1128.)

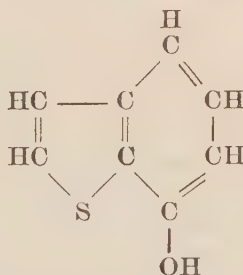
*Chlorophyll and the Reduction of Carbonic Acid by Plants*, by C. Timiriazeff.—On subjecting an alcoholic solution of chlorophyll to nascent hydrogen (by means of zinc and acetic acid) the chlorophyll is reduced, and forms in dilute solutions a straw-yellow substance and in concentrated solutions a substance of brown-red color. This substance has a well-defined spectrum, in which the band in the red portion characteristic of chlorophyll is wanting. The most important property of this reduced chlorophyll is its rapid oxidation on exposure to air, with reproduction of green chlorophyll. The author terms this new substance protochlorophylline, or, more briefly, protophylline.

Solutions of protophylline can be preserved only in glass tubes hermetically sealed. If a solution of protophylline be sealed up in a tube together with carbonic acid and preserved in total darkness it retains indefinitely its color and characteristic spectrum, but on exposure to sunlight the solution turns green. The author remarks that in the absence of quantitative details he can not claim that this proves the reduction of carbonic acid by protochlorophylline in the presence of

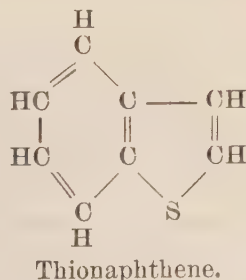
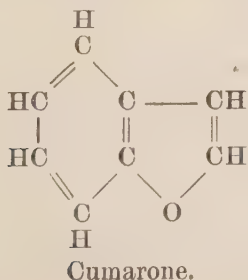
sunlight, but he can not find any other explanation of the facts. He thinks that there is evidence of the existence of protophylline in living plants. He also finds that by pushing the reducing action of nascent hydrogen further another and colorless substance is obtained, which is now under examination. (Comptes Rendus, CII, 687.)

*Acetophenone, a new Hypnotic.*—Acetophenone, also called acetylbenzene,  $C_6H_5 \cdot CO \cdot CH_3$ , has been found to possess valuable hypnotic properties. It is as yet only a laboratory product, but there should be no great difficulties in manufacturing it on a commercial scale. It is commonly obtained by distilling a mixture of calcium benzoate and calcium acetate, though many other methods are named in hand-books. It forms at ordinary temperatures a clear, colorless liquid, having a persistent characteristic odor; at a lower temperature it forms large flaky crystals, melting at  $20^{\circ}.5$  C. Dr. Dujardin-Beaumetz, who has discovered its hypnotic properties, recommends it for simple insomnia, and says its use is not followed by disagreeable after-symptoms, such as nausea, headache, etc. He proposes for this substance the trade-name "hypnone." (Bull. Générale de Thérapeutique, 1886.)

*On Thionaphthenes*, by Victor Meyer.—The author states that the first thiophene of the naphthalene series, which he names thionaphthene, has been obtained in his laboratory by A. Biedermann. It has the constitution



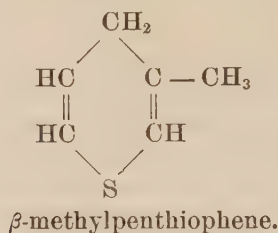
The author has obtained thionaphthene itself by the action of phosphide of sulphur on cumarone, the analogies of which are shown by the following schemes:



(Ber. d. chem. Ges., XIX, 1432 and 1615.)

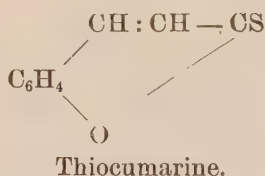


*On Penththiophene and its Derivatives*, by Karl Krekeler.—The existence of a body analogous to thiophene, but having five carbon atoms and one of sulphur in a closed chain, has been foreseen by Victor Meyer and others. The author obtained a methyl derivative by acting on  $\alpha$ -methylglutaric acid with sulphide of phosphorus, this acid being derived from lævulinic acid, a substance on which the author has lately experimented much. The body has the formula



This substance forms a colorless oily liquid, boiling at  $134^\circ \text{C}.$ ; its specific gravity = 0.9938 at  $19^\circ \text{C}.$  It gives the Laubenheimer color-test and other colored reactions. (Ber. d. chem. Ges., XIX, 3266.)

*Thiocumarine and its Derivatives*, by Fred. Tiemann.—By the action of phosphorus pentasulphide on cumarine the author obtained a sulpho-compound having the constitution

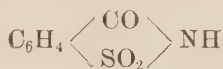


This crystallizes in golden needles, easily soluble in alcohol, ether, and benzene, insoluble in water, and melting at  $101^\circ$ . By reacting on this body with hydroxylamine he obtained cumaroxime in long white needles, melting at  $131^\circ$ . In appropriate ways the following compounds were obtained: Cumaroximethyl ether, dihydrocumaroxime, and a phenyl-hydrazine derivative of cumarine. (Ber. d. chem. Ges., XIX, 1661.)

*Benzoic Sulphinide, or so-called "Saccharine."*—Dr. Ira Remsen, assisted by C. Fahlberg, in the year 1879, when engaged in researches originating with the former, discovered a substance which he named benzoic sulphinide. This body, which may also be called anhydrosulphaminebenzoic acid, was obtained by the oxidation of orthotoluenesulphamide, and in the original paper (by R. and F.) is thus described: "Benzoic sulphinide is difficultly soluble in cold water. It is much more soluble in hot water, and can be obtained in crystalline form from its aqueous solu-

tion. It crystallizes in short, thick prismatic forms, which are not well developed. Alcohol and ether dissolve it very easily. It fuses at  $220^{\circ}$  (uncorr.), but undergoes at the same time partial decomposition. It possesses *a very marked sweet taste, being much sweeter than cane sugar*. The taste is perfectly pure. The minutest quantity of the substance, if placed upon the tip of the tongue, causes a sensation of pleasant sweetness throughout the entire cavity of the mouth. As stated above, the substance is soluble only to a slight extent in cold water, but if a few drops of the cold aqueous solution be placed in an ordinary goblet full of water, the latter then tastes like the sweetest sirup. Its presence can hence easily be detected in the dilutest solutions by the taste. Orthonitrobenzoic acid has this same property, but the sweetness is by no means so intense as in the case of benzoic sulphinide." (Am. Chem. J., I, 430.)

On the 2d of February, 1886, Dr. Ivan Lewinstein read a paper before the Society of Chemical Industry on "Saccharine," in which he gives sole credit of the discovery of this sweet substance to Dr. Remsen's assistant. The process of preparing it is the same, though he prefers for it the name benzoyl-sulphonic-imide, or the trade-name "saccharine." The constitution of this body is thus shown:



Dr. Lewinstein gives the following account of the properties and prospective uses of this substance:

Saccharine presents the appearance of a white powder, and crystallizes from its aqueous solution in thick short prisms, which are with difficulty soluble in cold water, but more easily in warm. Alcohol, ether, glucose, glycerole, etc., are good solvents of saccharine. It melts at  $200^{\circ}$  C., with partial decomposition; its taste in diluted solutions is intensely sweet, so much so that one part will give a very sweet taste to 10,000 parts of water. Saccharine forms salts, all of which possess a powerful saccharine taste; it is endowed with moderately strong antiseptic properties, and is not decomposed in the human system, but eliminated from the body without undergoing any change. It is about two hundred and thirty times sweeter than the best cane or beet-root sugar. According to Dr. Stutzser, of Bonn, who has carefully investigated the physiological properties of this substance, saccharine, taken into the stomach in the quantities in which it has to be added to food as a sweetening material, has no injurious effect whatever on the human system. Stutzser has given to dogs about 5 grams a day, without observing any ill effects in them, and when we consider that 5 grams are equal in sweetening power to rather more than  $2\frac{1}{4}$  pounds of sugar, a quantity far larger than any one would like to consume in a day, his view seems amply corroborated by this fact alone; but, in addition to this, patients suffering from diabetes have now been treated for several months in one of the principal hospitals in Berlin, as I am informed, without their feeling the least inconvenience by its use. Physicians must be glad to find in saccharine a substance, by means of which di-

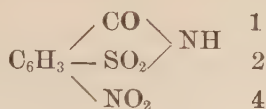
abetic persons may enjoy food which has hitherto not been admissible in their case. Saccharine does not belong to the class of carbohydrates, and does not possess nutritious properties. The use of saccharine will therefore, as indicated by its properties, be not merely as a probable substitute for sugar, but it may even be applied to medicinal purpose where sugar is not permissible. The inventor was fully aware that in order to supply a perfect substitute for cane or beet-root sugar, something else, viz, a similar substance, was needed for confectionery and similar purposes, besides sweetening properties, and he has also endeavored to solve this problem. Dr. Fahlberg combines glucose with starch sugar, a substance very similar to cane or beet-root sugar, but inferior to these in sweetening properties, with saccharine, and thus obtains a compound which he calls "dextro-saccharine," which, as far as the taste is concerned, is scarcely distinguishable from the best sugar. The quantity of saccharine used is in the proportion of one part to from 1,000 to 2,000 parts of glucose. Now, since the price of saccharine is at present about 50s a pound, we shall find that even at this price such a mixture would be very considerably cheaper than real sugar, but we must bear in mind the fact that there is great likelihood of the process of manufacture of saccharine being considerably cheapened.

It will then be evident not only that saccharine is a most interesting compound, but that it may also be destined to become an article of primary commercial importance. The future must decide as to the revolutions it may bring about in the coal-tar industry, in the cultivation of the soil now devoted to growing canes or beets, and in the sugar industry generally and other industries connected with it; but as great and important commercial interests are in question, it is highly advisable to look well into this matter, and not allow our foreign competitors in this and other markets to secure for themselves exclusively the benefit which this discovery may confer. There are in commerce small balls made from starch, to which has been added .05 per cent. of saccharine, of which one is sufficient to impart a very sweet taste, very similar to that of the best sugar, to a large cup of black coffee.

*Investigations on the Sulphinides*, by Dr. Ira Remsen.—The benzoic sulphinide described in the preceding note has been further studied by the author. By the substitution of the ethoxyl group for hydrogen paraethoxybenzoic sulphinide was obtained, crystallizing in fine white needles, melting at  $257^{\circ}$  to  $258^{\circ}$ . This derivative has not the sweet taste characteristic of the benzoic sulphinide. Another derivative, parabrombenzoic sulphinide, crystallizing in long needles and subliming in feathery flakes at about  $200^{\circ}$ , has a remarkable taste. When first placed upon the tongue its taste is extremely sweet, fully as much so as that of benzoic sulphinide, a single small crystal being able to sweeten half a liter of water. After the sweet taste has passed an equally bitter taste takes its place, reminding one in its extreme bitterness of strychnine. This peculiarity can not be due to the presence of two substances of different degrees of solubility, since the purest specimens have this property. (Am. Chem. J., VIII, 223.)

*Paranitrobenzoic Sulphinide, etc.*, by W. A. Noyes.—This body crystallizes in small leaflets and in fine needles, fusing at  $209^{\circ}$ . It is diffi-

cultly soluble in cold water and (together with its salts) has an intensely bitter taste. Its structure is as follows:



Para-amidobenzoic sulphinide, on the other hand, has an intensely sweet taste. Its solution, even when very dilute, shows a dark-blue fluorescence. The author describes its salts with potassium, barium, and silver. (*Am. Chem. J.*, VIII, 167.)

*On Wrightine*, by H. Warnecke.—This alkaloid, first isolated by Stenhouse in 1864, from the seeds of *Wrightia antidysenterica*, an apocynaceous tree from India. It is the first known solid base occurring in nature which is free from oxygen. If a trace of this base, dissolved in chloroform, is evaporated to dryness in a porcelain capsule, the residue covered with 2 to 3 c. c. of water and strong sulphuric acid is added in a slender stream, a golden-yellow color spreads from the bottom of the capsule through the whole liquid, and turns to a green on standing for twelve hours. If 1 milligram of the alkaloid is rubbed up in a watch-glass with five drops of strong sulphuric acid and let stand exposed to the air for two hours, the liquid which was at first colorless, turns yellowish green and finally a pale violet. If the above mixture is at once exposed in the neck of a flask to the steam of boiling water the mass turns dark green, and passes into deep blue on contact with a little water. (*Ber. d. chem. Ges.*, XIX.)

*Chemical Aspects of Future Food Supply*.—The chemical section of the American Association for the Advancement of Science, at the meeting in Buffalo, August, 1886, was numerously attended. The president of the section, Dr. Harvey W. Wiley, addressed the members on "The Economical Aspects of Agricultural Chemistry." His concluding sentences on the *Future Food Supply* are as follows: "Since, with a proper economy, the natural supplies of potash and phosphoric acid, as we have seen, may be made to do duty over and over again, and last indefinitely, the economist who looks to the welfare of the future need have no fear of the failure of these resources of the growing plant. Indeed, it may be said that the available quantities of them may be increased by a wise practice of agriculture, based on the teachings of agricultural chemistry. But with the increase of population comes an increased demand for food, and therefore the stores of available nitrogen must be enlarged to supply the demands of the increased agricultural product. It is certain, that with the new analytical methods, and the new questions raised by the investigations of which I have spoken, many series of experiments will be undertaken, the



outcome of which will definitely settle the question of the entrance of free nitrogen into vegetable tissues. If this question be answered affirmatively, agricultural science will not place bounds to the possible production of foods. If the nitrifying process does go on within the cells of plants, and if living organisms do fix free nitrogen in the soil in a form in which at least a portion of it may be nitrified, we may expect to see the quantities of combined nitrogen increase *pari passu* with the needs of plant life. Thus, intensive culture may leave the gardens and spread over the fields, and the quantities of food suitable for the sustenance of the human race be enormously increased. In contemplating the agricultural economies of the future, however, it must not be forgotten that a certain degree of warmth is as necessary to plant development as potash, phosphoric acid, and nitrogen. If it be true, therefore, that the earth is gradually cooling, there may come a time when a cosmic athermancy may cause the famine which scientific agriculture will have prevented. Fortunately however for the human race the cereals, the best single article of food, are peculiarly suitable to a cold climate. Barley is cultivated in Iceland, and oatmeal feeds the best brain and muscle of the world in the high latitudes of Europe. It is probably true that all life, vegetable and animal, had its origin in the boreal circumpolar regions. Life has already been pushed half-way to the equator, and slowly but surely the armies of ice advance their lines. The march of the human race equatorwards is a forced march, even if it be no more than a millimeter in a millennium. Some time in the remote future the last man will reach the equator. There, with the mocking disk of the sun in the zenith, denying him warmth, flat-headed and pinched as to every feature, he will gulp his last mite of albuminoids in his oatmeal, and close his struggle against an indurate hospitality." (*Economical Aspects of Agricultural Chemistry, an Address by H. W. Wiley. Cambridge, 1886.*)

*Recent Progress in the Coal-Tar Industry.*—Under the above title Sir Henry E. Roscoe delivered a most valuable and interesting discourse at the Royal Institution on April 16, 1886. He refers the numerous products, whether dye-stuffs, perfumes, antipyretic medicines, or sweet principles to two great classes of hydrocarbons, the paraffinoid and the benzenoid hydrocarbons. The first is the foundation of the fats, and the second of the essences or aromatic bodies. Petroleum is the source of the first class and coal-tar of the second. The following tables give an interesting view of the marvellous products of coal and their relative amounts.

I. Products of distillation of 1 ton of Lancashire coal:

10,000 cubic feet gas.

20 to 25 gallons ammoniacal liquor (5° Tw.).

12 gallons of coal-tar (= 139.2 pounds, specific gravity, 1.16).

13 hundredweight of coke.

## II. Products of 12 gallons of gas-tar :

- 1.10 pounds benzene (= 1.10 pounds aniline) } = 0.62 pound magenta.  
 0.90 pound toluene (= 0.77 pound toluidine) }  
 1.5 pounds phenol proper (= 1.2 pounds Aurin).  
 2.44 pounds solvent naphtha (three xylenes).  
 2.40 pounds heavy naphtha.  
 6.30 pounds naphthalene (= 5.25 pounds  $\alpha$ -naphthylamine, 7.11 vermilline  
 scarlet RRR, or 9.50 pounds naphthol yellow).  
 17.0 pounds creosote.  
 14.0 pounds heavy oil.  
 0.46 pound anthracene (= 2.25 alizarine 20 per cent.).  
 69.6 pounds pitch.

## III. Dyeing power of colors from 1 ton of Lancashire coal :

Pounds.	Dye-stuff.	Dye yards of flannel 27 inches wide.
0.623	Magenta .....	500
[or, 1.23	Methylviolet ...	1,000 ]
9.50	Naphthol yellow..	3,800
[or, 7.11	Vermilline .....	2,560 ]
1.2.	Aurin .....	120
2.25	Alizarin .....	*255

\* Printers' cloth.

The distinguished lecturer illustrated the tinctorial power of the coal-tar products by exhibiting a party-colored flag showing the exact amount of color obtainable from 1 pound of Lancashire coal; this flag was made up as follows :

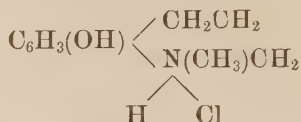
	Inches.
Magenta flannel .....	8 x 27
Violet flannel .....	24 x 27
Yellow flannel .....	61 x 27
Orange flannel .....	1.9 x 27
Turkey-red flannel .....	4 x 27

The colors chosen are only a few among the numerous list of derivatives. This list comprises at present the following :

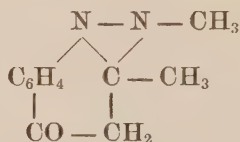
16 distinct yellows.	} Derived from benzene, toluene phenols, xylene, naphthalene, anthracene.
12 oranges.	
30 reds.	
15 blues.	
7 greens.	
9 violets.	
Several browns.	
Several blacks.	

The coal-tar antipyretic medicines next engaged the lecturer's attention. Professor Dewar discovered in 1881 that quinoline belongs to the

aromatic series, and first observed that certain pyridine salts act as febrifuges; so he may be called the father of antipyretic medicines. Of these, kairine was discovered by Prof. O. Fischer in 1881, and its febrifuge properties were first noticed by Professor Filehne, of Erlangen. It is actually ethyl-tetraoxy-quinoline, and has the constitution



Antipyrine, the second of these febrifuges, was discovered by Dr. L. Knorr, of Erlangen, and its physiological properties were studied by Professor Filehne. It has the following constitution:



or  $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}$ . For the preparation of these bodies and their physiological effects, as well as for brief notices of cumarine and vanilline, we refer to the original address. (*Nature*, xxxiv, pp. 111 and 133.)

*Statistics of the Coal-Tar Color Industry.*—In a paper on the scientific development of the coal-tar color industry, by Prof. R. Meldola, before the Society of Arts, he gives some statistics showing the magnitude of the industry under discussion. In Germany a factory of about the third magnitude consumes at present 500 to 600 tons of aniline per annum. The Badische Company employ twenty-five hundred laborers and officials, and the Hoechst Color Works (formerly Meister, Lucius & Brünig) employ sixteen hundred men and fifty-four chemists. In these large establishments they manufacture not only aniline, but alizarine, acids, alkalies, and all the necessary chemicals.

The probable consumption of alizarine by British dye-works in 1886 amounted to 6,900 tons (of 10 per cent. paste), of which perhaps 65 per cent. was manufactured in Germany. The author points out that although historically the industry is indebted to English discoveries, commercially the control is leaving England for Germany. (*Nature*, xxxiv, 324.)

#### NOTES.

Gadolinium is the name definitely given by Marignac to the metal  $\text{Y}\alpha$ , which he discovered in 1880. The provisional name was abandoned at the suggestion of Lecoq de Boisbaudran. This is not to be confounded with the same word as used by Nordenskjöld.

Ammonio-permanganate of silver, as well as the analogous compounds of copper, cadmium, nickel, zinc, and magnesium are new compounds

obtained by J. Klobb. They are all explosive when heated or struck by a hammer. (*Comptes Rendus*, CIII, 384.)

The decomposition of chlorine water in sunlight is shown by A. Popper to yield, besides the usually admitted oxygen and hypochloric acid, chloric acid itself, and he shows that this was not formed by the treatment to which the liquid was subjected for analytical purposes. (*Ann. Chem.*, CCXXXI.)

Phosphorus tetroxide,  $P_2O_4$ , has been obtained by Thorpe and Tutton. It forms when phosphorus is burned in a limited supply of dry air. It occurs as transparent, highly lustrous, very deliquescent crystals, which do not fuse at  $100^\circ$ , and do volatilize at  $180^\circ$ . On solution in water they form phosphoroso-phosphoric acid, previously discovered by Salzer. For reactions of this oxide and other details see original paper. (*J. Chem. Soc., Trans.* 1886, 833.)

The thickness of the air layer adhering to glass has been carefully measured by Otto Schumann and found to be somewhat less than  $0.000007^{cm}$ . O. E. Meyer estimates the diameter of molecules at  $0.000000005^{cm}$ ; the air layer is therefore more than one thousand times as large as the diameter of molecules. (*Wiedemann's Annalen*, XXVII, 91, '86.)

Attention is called by Arthur G. Bloxam to the solubility of sulphur in alcohol, a fact not generally noted in text-books. By slowly cooling a solution of sulphur in hot alcohol he obtained brilliantly transparent crystals up to half an inch in length, and so white as easily to be mistaken for niter. Chemists using rubber corks in distilling alcohol should bear in mind this solubility of sulphur as a possible source of impurity. (*Chem. News*, LIII, 181.)

Tyrotaxon is the name given to a highly poisonous ptomaine discovered by Dr. Victor C. Vaughan in cheese. Its occurrence in poisonous ice-cream has also been demonstrated by Dr. Vaughan, who presented a paper on the subject to the Michigan State Board of Health, July 13, 1886.

Lecoq de Boisbaudran remarks the fluorescence of manganese sulphate when mixed with a large amount of calcium sulphate and subjected to electrical action in a vacuum. Sulphate of manganese alone does not fluoresce under these conditions. (*Comptes Rendus*, CIII, 463.)

Cæsium and rubidium nitrites, according to Th. Rosenblatt, form with cobalt nitrite crystalline double salts, which are the least soluble compounds of these alkaline metals yet discovered. Cæσιο-cobaltic-nitrite requires 20,100 parts of water at  $17^\circ C.$ , and the rubidium salt 19,800 parts for solution. Thallium forms similar compound. (*Ber. d. chem. Ges.*, XIX, 2531.)

The oxides of gold have been critically studied by Gerhard Krüss, who finds there are three only:  $Au_2O_1$ ,  $Au_2O_2$ , and  $Au_2O_3$ . All attempts to obtain lower or higher oxides were futile. (*Ber. d. chem. Ges.*, XIX, 2541.)



Iodine is reported by J. A. Wanklyn to exist in a free state in the mineral water of the Woodhall Spa, near Lincoln. Sufficient is present to impart a brown color to the water and to give the usual reaction with carbon disulphide. The spa has long been known as useful in skin diseases. (Chem. News, LIV, 300.)

The complete synthesis of pyrrol has been accomplished by Ciamician and Silber; the steps in the transformation from succinimide to pyrrol are as follows: Succinimide, bichlormaleïnimide, perchloride of tetrachlorpyrrol, tetrachlorpyrrol, tetraiodpyrrol, pyrrol. (Ber. d. chem. Ges., XIX, 3027.)

Combinations of acetamide with metallic chlorides have been described by G. André, notably with cupric chloride, cadmium chloride, the chlorides of nickel and cobalt, and mercuric chloride. These bodies are crystalline, and decompose at a moderately low temperature. (Comptes Rendus, CII, 115.)

Prof. A. Michaelis, of Aachen, continues his extended researches on compounds of the elements of the nitrogen group with radicals of the aromatic series. In Liebig's Annalen, Vol. CCXXXIII, in union with A. Reese, he describes several compounds of antimony with phenyl and its derivatives, and in union with Paetow he describes compounds of arsenic with benzyl.

Calced magnesia, showing peculiar behavior with reagents, is supposed by George Stillingfleet Johnson to contain rare earths. (Chem. News, LIV, 88.)

The mosandra of Dr. J. Lawrence Smith has been examined by Lecoq de Boisbaudran, samples being furnished by Dr. Marion, of Louisville, and found to consist chiefly of terbia and  $Y\alpha$ . (Chem. News, LIII, 168.)

Sozolic acid, or orthoxyphenylsulphurous acid, discovered by M. Ser-rant, is a more powerful antiseptic than salicylic or phenic acids. The corresponding *para* compound has no antiseptic properties. The author claims for sozolic acid great benefits to medicine and surgery. (Comptes Rendus, CII, 1079.)

A summary of all that is known concerning samarium and its compounds has been published by P. T. Clève, of Upsala. The subject is treated under the heads history, separation, mode of occurrence, atomic weight, spectrum, oxides, and the numerous salts. (Chem. News, LIII, 30 *et seq.*)

Cerium, yttrium, and glucinum, according to Dr. J. H. Strohecker, occur in extraordinary quantities in the clays of Hainstadt. One of the clays analyzed contained as high as 13.4 per cent. cerium hydroxide. The author's analytical methods and his statements have met severe criticisms on the part of several chemists, but he insists on their accuracy. (J. f. prakt. Chemie, 1886.)

Glycyphyllin is a crystalline substance, which Dr. Edward H. Ren-nie extracted from the leaves of *Smilax glycyphylla*, a plant common in New South Wales. Crystallized from water it has the formula

$C_{21}H_{24}O_9 + 4\frac{1}{2}H_2O$ . On boiling with dilute sulphuric acid it decomposes into phloretin and isodulcite, and is therefore closely allied to phlorizin. (J. Chem. Soc., Trans. 1886, 857.)

According to Dr. F. W. Dafert, starch obtained from *Panicum candidum* yields with iodine a reddish brown color instead of the usual blue coloration. (Biedermann's Centralblatt, 1886.)

The formation of ferrates can be conveniently exhibited in a lecture by a method described by C. L. Bloxam. Place a fragment of potassium hydroxide in a solution of ferric chloride, add a few drops of bromine, and heat gently. The resulting dark brown mass dissolves in water, yielding a fine red solution, which may be kept many hours without decomposition. By boiling ferric chloride with bleaching powder a similar red solution of calcium ferrate can be obtained. (Chem. News, LIV, 43.)

A new alloy of aluminium and tin (100Al : 10Sn), having a specific gravity of 2.85, is recommended by M. Bourbowze for all instruments requiring lightness. It can be soldered as easily as brass, and resists reagents almost as well as aluminium itself. (Comptes Rendus, CII, June 7, 1886.)

The third annual convention of the Association of Official Agricultural Chemists was held August 26 and 27, in Washington, D. C., under the presidency of Dr. Harvey W. Wiley. The members adopted official methods for determining phosphoric acid and moisture and for potash, but agreed not to select any single method for the determination of nitrogen as official. Details of the methods adopted and other papers of value will be found in the proceedings, published as Bulletin 12 of the Division of Chemistry, Department of Agriculture.

The Berichte of the German Chemical Society in Berlin grows apace; the volumes for 1885 contain 3,516 pages of contributions and 1,033 pages of abstracts, making a total of 4,549 pages. The society has ordered for 1886 an edition of 3,600 copies.

The Tōkyō Chemical Society (of Japan), organized in 1878 by the graduates of the Tōkyō University, has eighty-six members. The officers for 1886 are as follows: President, J. Sakurai; vice-presidents, T. Isono, M. Kuhara, N. Matsui, J. Takayama, G. Nakasawa; secretary, T. Uyeda; treasurers, T. Isido and T. Takamatsu. The members are exclusively Japanese (no foreigners). They meet twice a month and publish a journal in Japanese entitled Tōkyō Kagakkai Kaishi, edited by J. Sakurai. The eighth annual meeting was held April 10, 1886, at the botanical garden of the Imperial University, Tōkyō, and several interesting addresses and papers were read.

The Chemical Society of London now numbers fourteen hundred and fifty-nine fellows, thirty-one of these being honorary foreign members. During the year 1885-'86 one hundred and four papers were read to the society, a larger number than for several years past. The income for the year named amounted to £3,743. A subject catalogue of the library

was recently published. The president for the current year is Dr. Hugo Müller, F. R. S., and the first vice-president is William Crookes, F. R. S.

The twelve principal chemical societies of the world have nearly nine thousand members, distributed as shown in the following table (from H. C. Bolton's Address to N. Y. Academy of Sciences, March 15, 1886):

Deutsche chemische Gesellschaft zu Berlin.....	2,950
Society of Chemical Industry (England).....	2,400
Chemical Society of London.....	1,500
Société chimique de Paris.....	560
Institute of Chemistry of Great Britain and Ireland.....	430
American Chemical Society.....	250
Society of Public Analysts (England).....	180
Chemical Society of St. Petersburg.....	160
Associazione chimico-farmaceutica fiorentina.....	*200
Chemical Society of Tokio, Japan.....	86
Chemical Society of Washington, D. C.....	48
Association of Official Agricultural Chemists (United States of America).....	17
Total.....	8,781

The centenary of the death of Scheele was commemorated on May 21, 1886, at the little town of Köping, Sweden, where he passed the last ten years of his life.

The prodigious activity in all departments of science obtaining in Germany is well illustrated by statistics of the meeting of "deutscher Naturforscher und Aerzte" held at Berlin in September, 1886. At this meeting no less than 5,651 persons took part, including 2,224 members, 1,931 associates, 1,496 women. Nearly every quarter of the globe was represented. North America by 42 persons, Japan by 16, India by 2, Egypt by 4, Australia by 4, and the Cape of Good Hope by 2. In the 30 sections into which the association is divided 522 lectures and 155 experimental demonstrations were held in 131 sessions. And those in attendance were invited to join 48 excursions.

The first meeting of this association was held in 1821, in Leipzig, and was attended by 13 persons; surely small beginnings are not to be despised.

#### NECROLOGY OF CHEMISTS, 1886.

ROBERT ALEXANDER, a young English chemist of much promise, was killed instantly during the disastrous earthquake in Charleston, South Carolina, August 31, 1886. He was born March 18, 1863, near Birkenhead, England. His chemical education was chiefly in the analytical laboratory of Mr. G. W. Wigner, London. In January, 1886, he came to America, and in March went to Charleston, where he was engaged in developing a sanitary system when he met his death.

JAMES APJOHN died June 2, 1886, at the advanced age of ninety-one. He held the chair of chemistry in the Royal College of Surgeons, Dub-

\* Estimated. Many chemists are members of several societies; against this duplication may be set those chemists not connected with societies.

lin, from 1828 to 1850, and in the University from the latter date until 1874. He published many original memoirs on general physics and chemistry, and long held a foremost place as a theoretic and practical chemist.

H. A. BAYNE, professor of chemistry at the Royal Military College, Kingston, Ontario, died in September. He was a native of Nova Scotia. After graduating at Dalhousie College, Halifax, he studied chemistry with Bunsen and with Dumas. He had occupied the chair of chemistry at Kingston only since 1879.

APPOLINAIRE BOUCHARDAT, born in 1806, died April 7, 1886. He held since 1852 the chair of physics and organic chemistry in the College of Pharmacy of Paris. His investigations were chiefly in the field of pharmaceutical chemistry. He edited the "Annuaire de thérapeutique" from 1841 to 1885, the "Répertoire de pharmacie" from 1847 to 1872, and other important works. He was a member of many learned societies.

CARL BULK died in July, in the forty-first year of his age. He was a teacher in the Gewerbeschule in Barmen, and chemist to the Barmen Color Manufactory (Farben-Industrie), which makes a specialty of aniline dyes. Dr. Bulk was an original member of the German Chemical Society.

ALEXANDER MICHAILOWITSCH VON BUTLEROW died August 17, 1886. He was born September 6, 1828, in the province of Kasan, was at first a pharmacist, and then studied in the universities of Kasan and of Moscow. In 1854 he became professor of chemistry at Kasan and in 1869 at the University of St. Petersburg, which chair he held at his death. His original researches were chiefly in organic chemistry, and gained for him a world-wide reputation.

HENRY SUGDEN EVANS, born at Islington, England, in 1830, died in Montreal in 1886. He was president of the Pharmaceutical Society and chief analyst to the Dominion of Canada. His publications were chiefly in pharmaceutical chemistry.

GOTTLIEB C. FAAS, a student of chemistry residing in Birmingham, Alabama, was killed by a locomotive October 3, in Pennsylvania.

FRANCESCO FILIPPUZZI, of Padua, died July 22, 1886. He was born in 1824, and after receiving his education in Austria was appointed professor of chemistry at the University of Padua, where he organized practical courses modeled on those of German universities. Though not eminent as an investigator he will long be remembered as a teacher by numerous grateful pupils. A fuller notice will be found in Ber. d. chem. Ges., XIX, 2941.

CHARLES FROEBEL died June 19, 1886. He was professor of analytical chemistry in the New York College of Pharmacy from 1872 to 1882.

FREDERICK GUTHRIE, born October 15, 1833, died October 21, 1886. From 1861 to 1867 he held the chair of chemistry and physics in the



Royal College, Mauritius, and since 1869 the chair of physics in the Royal School of Mines, London. His original contributions to both sciences were numerous and important. He founded in 1873 the Physical Society of London. Guthrie was also the author of several works on heat, electricity, and molecular physics.

FÉLIX LEBLANC died in Paris in May (?), 1886. He was for many years a co-laborer with Dumas, and at his death was connected with the École Centrale des Arts et Manufactures, in Paris. His studies on carbon monoxide are noteworthy. He was vice-president of the Society for Encouragement of National Industries, and member of many learned societies.

E. LINNEMANN, professor of chemistry at the University of Prague, died April 27, 1886. He was born in 1841. For an account of his scientific labors see *Ber. d. chem. Ges.*, XIX, 1149.

FREDERIC MELSENS died in Brussels April 20, 1886, aged seventy-two years. He was an active investigator in both inorganic and organic chemistry throughout his life.

MOSER VON MOOSBRUCH, of Vienna, an agricultural chemist, died early in the year 1886.

WILLIAM RIPLEY NICHOLS died July 14, aged thirty-nine. He held the chair of general chemistry in the Massachusetts Institute of Technology, of which he was a graduate. He was the author of several text-books, and had a high reputation as an expert chemist in matters pertaining to hygiene.

MAX REIMANN died October 22, 1886. His investigations and writings for twenty years were chiefly in the line of industrial chemistry. For a biographical sketch see *Ber. d. chem. Ges.*, XIX (1886).

G. F. HEINRICH SCHRÖDER, born in Munich, September 28, 1810, died May 12, 1885. A full biography will be found in *Berichte der deutschen chemischen Gesellschaft*, XVIII, R., 843.

CHARLES UPHAM SHEPARD, the well-known American mineralogist, died May 1, 1886, in his eighty-second year. His chemical work was chiefly in connection with minerals. A full notice will be found in the *American Journal of Science*, Vol. XXXI, 482 (June, 1886).

EDWARD SOLLY died April 2, 1886, in the sixty-seventh year of his age. He was a member of the Royal Society.

JULIUS ADOLPH STÖCKHARDT, the well-known agricultural chemist, died at Tharandt, Saxony, June 1, in his seventy-seventh year. He was the originator of the agricultural experiment stations now so common in Europe and elsewhere. His text-book, "Principles of Chemistry," did much to popularize the science. He was editor of many journals devoted to scientific agriculture. For a fuller sketch of his life see *Popular Science Monthly* for June, 1881.

MAGNUS TROILIUS died April 19, in Philadelphia, Pennsylvania. He was a graduate of the Royal School of Mines of Stockholm, and held for several years the position of chemist to the Midvale Steel

Works. His "Notes on the Chemistry of Iron" was published during the year.

MARTIN WEBSKY, born July 17, 1824, died November 26, 1886. Since 1874 he has been professor of mineralogy at the University of Berlin, being the successor of Gustav Rose. His chemical work has been chiefly in connection with mining and mineralogy.

CLEMENS ZIMMERMANN, instructor in chemistry at the University of Munich, died March 27, 1885. He was born March 4, 1856, in Munich, and was consequently only twenty-nine years of age. Dr. Zimmermann was one of the most active and promising young chemists of Germany. His researches on the atomic weight of uranium and in analytical chemistry are classical. A full biography (with portrait) will be found in *Berichte der deutschen chemischen Gesellschaft*, XVIII, R., 826.

OTTO ZIUREK died May 11, 1886. He was born in Upper Silesia June 19, 1821. His literary and practical works were chiefly in the field of pharmaceutical chemistry. (*Ber. d. chem. Ges.*, XIX, 1316.)

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## MINERALOGY IN 1886.

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### GENERAL WORKS ON MINERALOGY.

The list of mineralogical text-books has received an important addition during the past year in the *Lehrbuch der Mineralogie*\* of Bauer. It is a work of nearly six hundred pages, and covers about the same ground as the mineralogy of Tschermak, noted in the reports of 1884 and 1885. It is especially strong in the chapters on physical mineralogy, and here gives much valuable matter that has not hitherto found its place into the text-books. The descriptions of species, though necessarily brief, give all that the ordinary student requires. A work of great magnitude and importance is the *Index der Krystallformen*, by Goldschmidt, the first volume of which was completed in 1886. This work, which, when completed, will make three large volumes of six hundred pages each, proposes to give complete lists of all the crystalline forms identified on the crystals of every species, with the literature, the symbols of different authors, and so on. The author has started out with the plan of putting this material in the form which he regards as most useful for a discussion of the mathematical relations of the forces involved in the making of the crystal. With this end in view he has developed a new system of symbols, and adopts a new plan in regard to the choice of the position of a crystal, taking that one which gives the simplest symbols and lends itself most readily to the representation of the forms on a plane of projection. This system of symbols is worked out with admiral thoroughness, both with respect to the methods of calculation adapted to it, and its relations to the other systems of symbols which have been employed from the time of Haüy down. The unity of the work, therefore, is a prominent feature, and the details of the plan have evidently been developed with great care. The practical student of minerals, however, will be inclined, at least at first, to regret the introduction of a new series of symbols, and he will question further whether the reasons given are sufficient to justify placing the crystals of the majority of the species in a new position, and in general not the one which is most convenient for the study of the crystal itself or for its comparison with those of related species.

\* For full titles of works mentioned see the Bibliography at the end of the chapter.

A supplementary volume to the second edition (1875) of Rammelsberg's *Handbuch der Mineralchemie* has recently been issued. It contains the new analyses of the past ten years with extended calculations and discussions of composition after the manner of the earlier volumes. These discussions are always suggestive and often throw important light upon knotty points of chemical relations; the suggestions in regard to the connection between species, new and old, are often to the point, but sometimes arbitrary and not sufficiently considered. The concluding part of vol. ix of the *Materialien zur Mineralogie Russlands*, by Kokscharow, including the final pages, has been issued. It contains a new determination of the form of the variety of xanthophyllite called walnewite; a discussion of the forms of topaz based upon the work of Des Cloizeaux and N. von Kokscharow, jr., with a large number of calculated angles; also a description of the new species mursinskite alluded to on a subsequent page.

The large volume of chemical and geological essays (second series), by T. Sterry Hunt, entitled *Mineral Physiology and Physiography*, contains with other interesting matter an extended chapter giving the author's views on mineral classification as applied to the silicates. A third volume of the *Mineral Resources of the United States* has been issued, containing, like its predecessors, a large amount of valuable information for those interested in the mining industries of the country. A Catalogue of Minerals, giving synonyms and also a brief statement of composition, has been prepared by A. H. Chester, and will be found useful by collectors. A work on the diamond (*Le Diamant*, etc.), by M. Boutan, forms a volume of Frémy's *Encyclopédie Chimique*. It gives an excellent summary of the subject, with full descriptions of the diamond diggings of South Africa and Brazil, illustrated by many plates.

The completion of the tenth volume of Groth's *Zeitschrift für Kristallographie und Mineralogie* is marked by the publication of a general index for the ten volumes. This has been expanded so as to be a very complete repertorium of mineralogical and crystallographic literature from 1876 to the beginning of 1885. This forms the first two hundred pages of the volume, the index proper making up the remainder. A new periodical has been commenced in Vienna, entitled *Annalen des k. k. naturhistorischen Hof-museums*; it is edited by the director of the Vienna Museum, Dr. Franz Ritter von Hauer, and in addition to the reports and notices connected with the museum it contains articles on subjects in the various branches of the natural sciences.

#### CRYSTALLOGRAPHY AND PHYSICAL MINERALOGY.

Among the contributions to crystallography, perhaps the first place belongs to the monograph on stephanite, by Karl Vrba.\* This is a species which has been carefully studied before, and the early deter-

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\* For references see the list of papers on mineral species on a following page.

minations of the elements by Haidinger (1824) and Schröder (1855) have been accepted as deserving much confidence. Vrba has had the advantages of a larger supply of material and better instrument, and his measurements are exceptionally precise; it is interesting, however, as showing the constancy of the species to note that the axes which he finally accepts are almost identical with those of Schröder and differ very little from those of Haidinger. Vrba adds a large number of new forms, and discusses the crystals from different localities minutely as to occurring planes and angles. The memoir is accompanied by ten plates, giving a spherical projection for the species, and a large number (49) of excellent figures.

Pyroxene and the allied species have been the subjects of several valuable memoirs. One of these is by Flink on several of the Swedish minerals of this group, including a number of varieties of diopside from Nordmark, also schefferite and rhodonite from Långban and Pajsberg. These papers are all published together in Groth's *Zeitschrift*; some of them appeared in the *Transactions of the Swedish Academy for 1885*—the paper on rhodonite was noticed in the *Report for 1885*. The memoir as a whole is admirably complete, giving not only a description of crystalline form with exact measurements, but also a determination of the optical characters, and, not less important the chemical composition, since it has been shown that in this group the optical constants and composition vary together. La Valle has published an extended memoir on the Ala diopside, illustrated by numerous figures, and giving some valuable additions to our knowledge of the form of the pyroxene from that famous locality. The same author has earlier (1834) given an account of the polysynthetic twins of diopside from Ala. Another paper by Götz gives the results of a study of crystals of diopside from several localities, showing a number of new forms. The paper closes with a convenient list of all observed planes with the authorities. The author wisely decides against accepting the new position for the species suggested by Tschermak, which, though it brings out the relation to the orthorhombic members of the group somewhat more clearly, results in giving the majority of the forms very complicated symbols. Solly has described axinite crystals from Botallack, and in his paper he has given a list of planes and also a long series of angles. The euclase from the Austrian Alps has been described by Köchlin. The inexhaustible subject of calcite has been discussed by several authors; an extended memoir is given by Cesàro of crystals from Belgian localities.

Eichstädt has given a new description of the gadolinite of Hitterö, with a new determination of the form, and a number of new planes. The suite of crystals in hand included the best material for the species ever obtained, and the axial elements seem, therefore, to be worthy of more confidence than those of Des Cloizeaux, though not differing very widely from them. The topaz of Durango, Mexico, has proved a fruit-



ful field for the discovery of new forms. Notwithstanding the large number of planes already credited to the species, the labors of N. von Kokscharow, jr., and Des Cloizeaux have resulted in adding many new ones to the list, some of them of complex symbols. The calculated angles for all these forms are given in the concluding part of vol. ix of the *Mineralogie Russlands*, already alluded to. Alling has measured the unusually perfect colorless topaz crystals from Utah and found them to agree closely in their elements with the Uralian crystals. Des Cloizeaux has extended his study of the vanadate bearing his name (descloizite) and proved conclusively on optical grounds that it is orthorhombic, not monoclinic in crystallization. Huntington has investigated the crystalline structure of native iron as shown by cleavage fragments and etched sections of meteorites, and has extended and developed our knowledge of that important subject.

Several papers have been published devoted to a crystallographic study of some American species. The phenacite from Florissant, Colorado, is described by Des Cloizeaux with figures representing a new form. Penfield has described complex crystals of brookite from Magnet Cove, Arkansas, and the writer of this report has continued the same subject, showing the unusual variety in form of the crystals from this locality; the latter work was based upon the fine suite of crystals in the collection of Mr. C. S. Bement, of Philadelphia. The Bement collection has also given, in the hands of the writer, material for an extended memoir on the crystallization of native copper of Lake Superior. The specimens from this locality are remarkably complex in form, especially in the twinning groups, and a series of some sixty figures in four plates were needed to illustrate the different forms. Another paper is devoted to the crystallization of gold from California and Oregon, and others to columbite, diaspore, etc.

The minerals from Alexander County, North Carolina, brought to light by the explorations of W. E. Hidden, have been crystallographically studied by vom Rath. The monazite has been figured and measured, more particularly the nearly symmetrical cruciform twins, with the orthopinacoid as the twinning plane, also described by Hidden. The spodumene (hiddenite) has been measured also, and has yielded a considerable number of new planes; the same is true of the quartz which has proved to be remarkably rich in interesting points. The locality has furnished, among other things, a few crystals showing the rare basal plane as noted by Hidden and Des Cloizeaux. The beryl is, too, exceptionally fine in crystallization, and having, as illustrated by vom Rath, a novelty and complexity of form surpassing the Uralian specimens. The same author has measured the North Carolina rutile and xenotime. The vanadinite of Arizona and New Mexico has been shown by Penfield to be highly complex in form, and to exhibit the pyramidal hemihedrism of the group with unusual distinctness for this species.

In the broader subject of physical mineralogy a large number of im-

portant contributions have been made, but for the most part they are of such a nature as not to allow of being mentioned briefly—titles are given on a following page. Among the more popular articles may be mentioned several on the subject of the specific gravity. Brauns discusses the use of methyl iodide for petrographic and optical investigations. Its specific gravity is 3.33; it has a very high index of refraction (1.7424 for Na at 14° C.) and remains unchanged in the air. It can be used in much the same way as the Thoulet solution for the accurate determination of the specific gravity, or the separation of different minerals mechanically mixed. It has the disadvantage that it can not be diluted with water, but with benzol, and moreover its specific gravity changes rather rapidly with change of temperature. A method of obtaining the specific gravity of small fragments of a mineral applicable, as the Thoulet solution is not, to minerals of specific gravity over 4, or, on the other hand, to porous bodies, is described by Joly. It consists briefly in determining the specific gravity, as by the Thoulet solution, of a little ball of paraffin in which the mineral fragments have been imbedded by careful heating; the weight of the paraffin and its specific gravity are known by previous observations. Goldschmidt has discussed the degree of accuracy attainable in the different methods of obtaining specific gravity and thrown some light upon the subject. In one of his papers he shows that the temperature-correction may in all ordinary mineralogical work be neglected, since it is considerably less in amount than the usual errors of observation. He also urges a point, the importance of which is too little understood, that the apparent wide variation in the specific gravity of a given mineral is in most cases due simply to the use of poor material, or to faulty determinations.

Mügge has made some additions to a subject previously developed by him: The existence of secondary twinning and the change in position of crystalline faces due to it; also the production of a twinning structure by pressure, as in bismuth, antimony, and diopside. This is a method of especial interest in the case of diopside, since natural crystals often show twinning lamellæ parallel to the basal plane, and in consequence there is often the distinct parting in this direction which was long called the basal cleavage. Judd has followed out a related line of investigation in his discussion of what he has called "schillerization," that is, the production of the peculiar, nearly metallic reflection called "schiller" by the secondary formation of inclusions in parallel position. He argues for the existence of planes of easy solubility ("solution-planes") along which chemical action takes place more readily, as in the formation of negative crystals. These planes of chemical weakness, he says, have with the cleavage planes and gliding-planes (Gleitflächen) a definite relation to the symmetry of the crystal. These solution-planes are hence connected with the planes of secondary twinning.

An interesting series of papers have been given by Kundt and Blasius, Mack and Schedtler, on the pyro-electricity of different minerals. The

paper of Schedtler on tourmaline is especially exhaustive, describing in detail the methods and results of the investigation. A series of plates show the remarkable distribution of the electrical condition over different crystals as exhibited by the arrangement of the red lead and sulphur powdered over them, after the method first proposed by Kundt. The subject of the specific heat of minerals has been investigated by Öberg and by Joly with interesting results. The latter author has also attempted to determine the relative fusing points of different minerals by means of an electrical current in connection with an apparatus which he calls a meldometer. He proposes some modifications in the accepted scale of fusibility (von Kobell's) based upon the results of his experiments.

#### CHEMICAL MINERALOGY.

A series of important papers devoted to an investigation of the chemical composition of some American species has been issued by F. W. Clarke. One of these embraces the group of minerals of Litchfield, Maine, and more especially the elæolite, cancrinite, and sodalite, with an alteration product of the latter called hydronephelite, described on a following page. The results of the analytical work on these minerals are accompanied by a discussion of their relation to each other, exemplified by structural formulæ. In a second paper the same author takes up the lithia micas, and gives the results of much careful chemical work upon them. Analyses are given of the lepidolite from several towns in Maine, viz, Rumford, Paris, Hebron, Auburn, and Norway. They lead to the generally accepted formula  $\text{Al}_2\text{LiKF}_2\text{Si}_3\text{O}_9$ , and show a variation in water and fluorine, probably to be explained by a replacement of the latter by hydroxyl. The iron-lithia micas of Cape Ann, Massachusetts, including the cryophyllite and lepidomelane (annite), are also investigated and shown to bear an important relation to each other. Still another paper, by the same author, in this case associated with J. S. Diller, is devoted to a chemical and microscopical investigation of the turquoise of New Mexico. Analyses of three distinct types were made: the bright blue slightly translucent variety, the pale blue, with slight greenish cast, and the dark green opaque kind. These analyses are compared with others of the Persian and California mineral by Church and Moore, respectively, and shown to agree as well as could be expected, considering the nature of the material. The composition is made out, as expressed by the formula  $2\text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_5 \cdot 5\text{H}_2\text{O}$ , with variable amounts of a copper salt,  $2\text{CuO} \cdot \text{P}_2\text{O}_5 \cdot 4\text{H}_2\text{O}$ . A detailed description of the microscopic appearance of the mineral and of the inclosing rock follows.

Penfield and Harper discuss at length the composition of beryl and herderite. The former subject had been earlier studied by Penfield (see report for 1885), with the result of showing that beryl often contains alkalis to an extent not before imagined, and also water of constitution. The true formula of the species was, however, left in



doubt. These latter analyses go to show that pure beryl conforms to the commonly accepted formula of the species, except for the water, which is uniformly present, corresponding in amount to about one-half molecule, and going off only upon very strong ignition. The analysis of herderite by the above authors leads to the formula  $\text{CaBe}(\text{F},\text{OH})\text{PO}_4$ , in which the fluorine is partly replaced by hydroxyl, the mineral yielding water when strongly ignited. In another paper these authors discuss the composition of the rare octahedral fluoride from Greenland, called ralstonite. The results go to show that it is a hydrous fluoride of aluminium, magnesium, and sodium, with, however, the fluorine in part replaced by hydroxyl. It is free from lime, which has been found by other analysts, probably because their material was slightly impure from the presence of a little thomsenolite. The well-known pseudomorphs of chlorite after garnet from the Lake Superior iron region and the superficially altered garnets from Salida, Colorado, have been investigated by Penfield and Sperry.

Doelter has followed out the synthetic line of investigation mentioned in the last report and has succeeded in the formation of pyrrhotite. The formula obtained on the basis of a new analysis of the Schneeberg pyrrhotite, as also of the artificial compound, is  $\text{Fe}_{11}\text{S}_{12}$ . The author expresses himself as opposed to the common idea that the composition is variable and regards  $\text{Fe}_{11}\text{S}_{12}$  as probably correct; this he separates into  $9\text{FeS} + \text{Fe}_2\text{S}_3$  or  $10\text{FeS} + \text{FeS}_2$ . Wheeler has contributed some additional facts in regard to the artificial lead silicate in hexagonal prisms from Missouri, describing the circumstances of its formation. The chemical composition of a number of rare minerals, samarskite, gadolinite, cerite, and others has attracted attention because of the complex character of the metallic earths obtained from them. A number of new elements have been named, and the spectroscopic investigations of Crookes, Boisbaudran, and others on the yttrium group have shown a complexity which the chemical examination had left unexpected. The subject is especially important in connection with what Crookes discusses under the "Genesis of the Elements." In the same line is the interesting discovery of a new element, Germanium, in the silver mineral argyrodite, an element allied to antimony, in some of its properties, and corresponding closely to *eka-silicium* in the periodic series of Mendelejeff. The properties of this element are summarized in the Journ. für prakt. Chemie, xxxiv, 177. Several contributions have been made to the micro-chemical study of minerals, by Haushofer, Streng, and Behrens, to which attention is called, though they hardly allow of being briefly abstracted here.

#### NEW MINERAL OCCURRENCES IN THE UNITED STATES AND ELSEWHERE.

Among the recent announcements of new mineral occurrences may be mentioned the rare species perylite from Caracoles, Chili; molybdenite



in hexagonal crystals, occasionally of great size (2 inches across) in Canada, in Renfrew County, Ontario; also large dodecahedral garnets up to nearly 10 pounds in weight at Salida, Colorado; fine crystallized celestite from Lampasas County, Texas; phenacite from Florissant, Colorado. Some of the cases are alluded to in the preceding pages. An interesting and novel occurrence is that of garnet and topaz in lithophyses in the rhyolite of Nathrop, Colorado. The lithophyses are more or less spherical cavities, partially filled by thin curved walls, concentrically arranged, and producing rose-like forms. These cavities contain minute crystals of sanidine, garnets of the spessartite variety, and beautiful prismatic crystals of topaz, usually of a pale bluish or wine-yellow color. This occurrence of topaz in the rhyolite of Nathrop is shown by Cross to be similar to the occurrence of the same mineral at Chalk Mountain, Colorado, and of the Thomas range in Utah.

The well known locality in Sharpe's Township, Alexander County, North Carolina, developed by W. E. Hidden, has recently yielded some remarkable mineral specimens. Among these are some very fine emeralds, unique in beauty of color, size, and perfection of form. The largest weighed 9 ounces, and was 3 inches long and  $1\frac{3}{4}$  in diameter. The emeralds occurred in a pocket extending 20 feet vertically, 4 feet in extreme length, and a foot across. The associated minerals were green muscovite, rutile, dolomite, monazite, and quartz. Some large crystals of spodumene (hiddenite) were also found; one of them was  $2\frac{3}{4}$  inches in length, and weighed one-half an ounce; its color was in part of the fine emerald color which makes the mineral prized as a gem.

#### NEW MINERALS.

*Argyrodite*.—A new ore of silver, exceptionally interesting, as containing a new element, Germanium. It was found in September, 1885, at the Himmelfirst mine, near Freiberg, Saxony, and has been named and described by Weisbach. It occurs in small crystals mostly grouped in rounded wart-like or reniform aggregates; also in masses with a flat conchoidal fracture. They belong to the monoclinic system, showing a prism of  $115^\circ$ , with a clinodome and one prominent hemi-pyramid. The axial ratio is  $a:b:c$  (vert.) =  $0.678:1:0.614$ ; also  $\beta = 70^\circ$ . Twins and drillings, sometimes in knee-shaped forms, were observed. The hardness = 2.5; specific gravity = 6.10. Luster metallic, color steel-gray, with a tinge of red, but becoming slightly violet with superficial tarnish. The composition has been determined by Winkler, who, after at first finding a loss of  $8\frac{1}{2}$  per cent. in the analysis, succeeded in proving the presence of a new element, to which he gave the name Germanium. The analysis, when completed, gave:

S	Ge	Ag	Fe	Zn
17.13	6.93	74.72	0.60	0.22 = 99.60

The element germanium is allied to arsenic and antimony, and has an atomic weight of 72.3 and a specific gravity of 4.7. The formula of the mineral is written  $3\text{Ag}_2\text{S} \cdot \text{GeS}_2$ .

*Arnimite*.—Described by Weisbach as a new hydrous sulphate of copper. It was found on the porcelain jasper of Planitz, near Zwickau, where it has been formed in the course of the burning of a bed of coal. It forms a green coating, which, under the microscope, is resolved into short needles or scales. Several analyses were made by Winkler, but the material was more or less impure, with gypsum, anhydrite, etc. Moreover, the assumption was made that the loss of 17 per cent. was to be taken as water. It is evident, therefore, that the composition settled upon is more or less uncertain, namely,  $\text{Cu}_5\text{S}_2\text{O}_{11} + 6\text{H}_2\text{O}$ . This requires:

$\text{SO}_3$	$\text{CuO}$	$\text{H}_2\text{O}$	
24.07	59.69	16.24	=99.81

This mineral seems to be most nearly allied to herrengrundite, and Weisbach suggests that the latter may be considered a calcium variety of arnimite. The name arnimite is given in honor of the von Arnim family, who for centuries have owned the Planitz coal works.

*Arsenolamprite*.—Named by Hintze as an independent form of metallic arsenic. The specimens under examination were from Chili. They corresponded in characters with the *arsenglanz* from Marienberg, long since described by Breithaupt, and by him also called *hypotyphite*. Frenzel, in 1874, examined the Saxon mineral, and arrived at the conclusion that it was probably a distinct species. The specific gravity is 5.3 to 5.5, or decidedly lower than that of ordinary arsenic (5.7 to 5.8); the hardness is also less. The luster is brilliant metallic, the color lead-gray with a tinge of blue, the streak black. The structure is foliated with distinct cleavage in one direction. An analysis yielded 98 per cent. arsenic, with small quantities of iron and silica in addition.

*Bruithachite*.—A name given by Macadam to a mineral found at Loch Bruithaich, Scotland, incrusting barite. It is stated to be clear, beautifully crystalline, with a tendency to a bluish tinge of color and very friable. It was mentioned by A. Wallace in a brief description of the Bruithaich locality. An analysis gave:

F	CaO	$\text{Na}_2\text{O}$	$\text{Fe}_2\text{O}_3$	$\text{SiO}_2$
10.01	87.04	1.70	0.59	0.54 = 99.88

A further examination is needed.

*Caracolite*.—Described by Websky as an oxychloride of copper with sodium sulphate from Caracoles, Chili. It occurs intimately associated with the rare mineral percyllite in colorless crystals aggregated in crusts. The crystalline form is made out to be orthorhombic, with pseudohexagonal symmetry due to twinning. It appears in obtuse hexagonal pyramids, with prism associated. By an examination in polarized light the

crystals are shown to be compound in nature. The axial ratio obtained is  $\bar{a} : \bar{b} : c = 0.5843 : 1 : 0.4213$ ; the prismatic angle is  $119^{\circ} 24'$ . An analysis of the best material available yielded uncertain results because of the admixture of pererylite. A definite composition is obtained only after a series of assumptions, which impair the reliability of the result. The caracolite and pererylite are taken as present in about the ratio of 6 : 1, and the final formula given for the former is  $\text{PbClHO} + \text{Na}_2\text{SO}_4$ , which demands:

Pb	Na	Cl	S	H	O
51.56	11.46	8.84	7.97	0.25	19.92 = 100

In view of the remarkable nature of the compound a further examination of purer material is needed.

*Dognaeskaite*.—Briefly mentioned by Krenner as a sulphobismuthite of copper, occurring at Dognaeska, in Hungary. It is massive, with a single perfect cleavage, and becomes gray or brown on exposure to the air. An analysis by Maderspach yielded S 15.75, Bi 71.79, Cu 12.23. It is associated with gold, pyrite, chalcocite, and bismite.

*Emmonsite*.—A ferric tellurite from the neighborhood of Tombstone, Arizona, named by W. F. Hillebrand after S. F. Emmons, of the U. S. Geological Survey. It occurs in translucent crystalline scales of yellowish-green color imbedded in a hard brownish gangue, consisting of lead carbonate, quartz, and a brown substance containing the hydrated oxides of iron and tellurium. The crystallization is regarded as probably monoclinic; the specific gravity is about 5. The result of several analyses, after impurities had been deducted, gave:

Te	Se	Fe	H <sub>2</sub> O
58.75	0.53	14.29	undetermined.

The conclusion reached is that the mineral is a ferric tellurite, but the formula is doubtful, and it needs further examination, based on purer material. A related, but according to Dr. Smith, a distinct species is his ferrotellurite.

*Harstigit*.—A new silicate of calcium, aluminium, and manganese, from Pajsberg, Sweden, named and described by G. Flink. It occurs with garnet and rhodonite in small prismatic crystals, having a prismatic angle of  $109^{\circ} 11'$ . The axial ratio is,  $\bar{a} : \bar{b} : c = 0.7141 : 1 : 1.01495$ ; the habit is something like that of chrysolite. No cleavage was observed. The hardness is 5.5, the fracture small conchoidal or splintery, the specific gravity 3.049. It is colorless, with vitreous luster. The optic axial plane is parallel to the brachypinacoid, and the axial angle in air is  $90^{\circ} 27'$  for yellow light. An analysis yielded:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MnO	FeO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O
38.94	10.61	29.23	12.81	tr.	3.27	0.35	0.71	3.97 = 99.89

The water goes off only on strong ignition, when the powdered mineral from being white becomes brownish black.

The empirical formula calculated is:



*Hydronephelite*.—A zeolitic mineral derived from the alteration of sodalite of Litchfield, Maine; it is named and described by Clarke and Diller. It is found in seams, yielding specimens 2 centimeters in thickness. It is white, lusterless, with the fracture of sodalite. Optical examination made it probable that it belonged either to the tetragonal or hexagonal system. The hardness is 4.5. An analysis yielded:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O
38.90	33.98	0.05	1.01	13.21	13.12 = 100.27

for which the formula  $\text{HNa}_2\text{Al}_3\text{Si}_3\text{O}_{12} + 3\text{H}_2\text{O}$  is calculated. The formula requires silica 39.29, alumina 33.41, soda 13.54, water 13.76. It is allied in composition to thomsonite, but contains soda.

*Kainosite* (or CÆNOSITE).—Described by A. E. Nordenskiöld as a new yttrium mineral and named from the Greek (*καίνομαι*, unusual) in allusion to its remarkable composition. The mineral is known thus far only from a single fragment of a six sided prism from Igeltjern on Hitterö. It is said to belong to the orthorhombic or monoclinic system, and shows two unequal cleavages at an angle of 90°, or nearly 90°. The color is yellow-brown, the hardness 5.5, the specific gravity 3.413, the fracture subconchoidal. The mean of two analyses gave:

SiO <sub>2</sub>	Yr <sub>2</sub> O <sub>3</sub> , Er <sub>2</sub> O <sub>3</sub>	Ce <sub>2</sub> O <sub>3</sub>	CaO	MgO	FeO	Na <sub>2</sub> O	CO <sub>2</sub>	H <sub>2</sub> O
34.63	37.67	tr.	15.95	0.03	0.26	0.40	5.90	5.26 = 100.10

The formula given is  $2\text{CaO} \cdot (\text{Y}_2\text{O}_3, \text{Er}_2\text{O}_3) \cdot 4\text{SiO}_2 \cdot \text{CO}_2 \cdot 2\text{H}_2\text{O}$ , requiring SiO<sub>2</sub> 34.67, Yr<sub>2</sub>O<sub>3</sub> 37.60 (at. weight = 260.3), CaO 16.18, CO<sub>2</sub> 6.35, H<sub>2</sub>O 5.20. The natural supposition that the carbon dioxide is due to admixed calcite is said to be proved to be untrue by microscopic examination.

*Kaliophilite*.—A mineral allied to nephelite described by Mierisch as occurring in the masses ejected from Mt. Somma, together with augite and melilite. It forms thick prisms or fine thread-like colorless crystals, probably belonging to the hexagonal system. An optical examination showed the mineral to be uniaxial with negative double refraction. The cleavage is basal, distinct; it is very brittle. The specific gravity is 2.602. An analysis yielded:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub> (Fe <sub>2</sub> O <sub>3</sub> )	CaO	K <sub>2</sub> O	Na <sub>2</sub> O
37.44	32.43	2.18	27.20	2.26 = 101.51

This corresponds to the formula  $\text{K}_2\text{Al}_2\text{Si}_2\text{O}_8$ , which is analogous to that of an anhydrous muscovite, and corresponds to nephelite, anorthite, and eucryptite, which contain sodium, calcium, and lithium, respectively,



in the place of the potassium. The name has reference to the high percentage of the last-named element.

*Lucasite*.—Another member of the large group of hydrated micas called vermiculites. It is described by T. M. Chatard, and named after Dr. H. S. Lucas, who has been connected with the emery industry of this country. It was found with corundum at Corundum Hill, Macon County, North Carolina. The physical characters are like the others of the group. Of the 10.76 per cent. of water contained, 3.78 went off at  $110^{\circ}$  C., and 6.98 at a red heat (blast lamp). An analysis (mean of two) of the substance, dried at  $110^{\circ}$ , gave:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	Cr <sub>2</sub> O <sub>3</sub>	FeO	MnO	CaO	MgO	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O
41.17	13.43	5.47	0.56	0.11	0.05	0.14	25.68	5.96	0.21	7.22 = 100

The ratio of silica to bases to water is 7 : 6 : 2.

*Mursinskite*.—Named after the locality by Kokscharow on the basis of a crystallographic study of two small crystals found thirty-two years ago at the beryl locality at Alabashka, near Mursinsk, Ural. It has not been possible since their discovery to obtain additional material. The crystals occurred imbedded in the beryl. They belong to the tetragonal system and show one pyramid prominently, with two subordinate of the other series, and several zirconoids. The terminal and basal angles of the fundamental pyramid are respectively  $127^{\circ} 32'$  and  $77^{\circ} 23\frac{1}{2}'$ , corresponding with a vertical axis,  $c=0.56641$ . The color is white to honey-yellow, transparent to semi-transparent. Hardness = 5 to 6, specific gravity uncertain, though a trial on the crystal weighing .04 gram gave P. v. Nikolajew 4.149. Nothing is known of the chemical composition. Kokscharow calls attention to the fact that the pyramidal angle corresponds nearly with the pyramid  $\frac{3}{2}P\infty$  of vesuvianite, but there appears to be no further relation between the species.

*Ptilolite*.—A new zeolitic mineral described by Cross and Eakins. The name is from *πτίλον*, *down*, in allusion to the delicate fibrous nature of the mineral. It is found in cavities of a vesicular augite-andesite, found in fragments in the conglomerate beds of Green and Table Mountains, Jefferson County, Colorado. These cavities are in some cases filled with chalcedony and quartz, or sometimes only lined with chalcedony, and upon this is deposited the ptilolite in delicate white tufts or spongy masses, consisting of short hair-like needles loosely aggregated. They appear to have parallel extinction. An analysis by Eakins gave:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O
70.35	11.90	3.87	2.83	0.77	10.18 = 99.90

This corresponds to the formula  $RA_2Si_{10}O_{24}+5H_2O$  or  $RO \cdot Al_2O_3 \cdot 10SiO_2+5H_2O$ , requiring, when  $R=Ca : K : Na=$

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	K <sub>2</sub> O	Na <sub>2</sub> O	H <sub>2</sub> O
69.86	11.87	4.04	2.95	0.80	10.48 = 100

The mineral is remarkable for its high percentage of silica.

*Pyrrhoarsenite*.—A new arseniate of manganese described by Igelström, and related to numerous hydrated arseniates of manganese, several of which (polyarsenite, xanthoarsenite, chondroarsenite) have been named by the same author. It occurs at the Sjö mines in the Grythyttan parish, Sweden, forming small veins and masses with tephroite, calcite, hausmannite, barite. It shows one cleavage, but has not yet been found in crystals. Optically it is singly refracting for the most part, with occasional anisotropic portions. The hardness is 4. The color is a yellowish red (hence the name from *πυρρος*, fire, i. e., fire-red), resembling potassium dichromate. It dissolves readily in hydrochloric and nitric acids. An analysis yielded:

As <sub>2</sub> O <sub>5</sub> (Sb <sub>2</sub> O <sub>5</sub> )	MnO	CaO	MgO	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub> , FeO	
58.06	17.96	18.68	3.58	ignition 0.85	1.02,	tr. = 100.15

The formula given is 3(Mn, Ca, Mg)O. As<sub>2</sub>(Sb<sub>2</sub>)O<sub>5</sub>.

*Schungite*.—A name given (1884) by A. von Idostranzeff to a form of amorphous carbon found in the crystalline schists of Schunga, in the Olenetzer government, Russia. It is the same substance that was named graphitoid by Sauer, as noted in the report for 1885.

*Stüvenite*.—A new alum occurring with other related minerals at the abandoned mine of Alcaparroso, near Copiapo, Chili, described by Darapsky. It occurs in slender acicular crystals 2 or 3 inches in length. An analysis yielded (mean of two):

SO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	MgO	Na <sub>2</sub> O	K <sub>2</sub> O	H <sub>2</sub> O
36.1	11.6	1.0	2.7	tr.	47.6

corresponding to (Na<sub>2</sub>, Mg)SO<sub>4</sub> + Al<sub>2</sub>S<sub>3</sub>O<sub>12</sub> + 24H<sub>2</sub>O. The name is given after the mining engineer, Enrique Stüven.

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- PECTOLITE.** Chemical investigation, Doelter, Jb. Min., I, 126.
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- PTILOLITE.** Jefferson County, Colorado, a new zeolite, W. Cross and L. G. Eakins, *Am. J. Sc.*, xxxii, 117.
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- ZIRKON.** Pfitschlgrund, Tyrol, crystals described, Gehmacher, *Zs. Kr.*, xii, 50.
- Laacher See, occurrence in lava, Hubbard, *Ber. nied. Ges. Bonn*, June 7.
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- ZORGITE.** Argentine Republic, analyses of related selenides, Heusler and Klinger, *Ber. chem. Ges.*, xviii, 2556, 1885.
- ZYGADITE.** See **ALBITE**.

## EXPLANATIONS OF ABBREVIATIONS EMPLOYED.\*

- Am. Ch. J.*—American Chemical Journal, Baltimore.
- Ann. Ch. Phys.*—Annales de Chimie et de Physique, Paris.
- Am. J. Sc.*—American Journal of Science, New Haven.
- Am. Phil. Soc. Philad.*—American Philosophical Society of Philadelphia. Proceedings.
- Ann. Mines.*—Annales des Mines, Paris.
- Ann. Mus. Wien.*—Annalen des naturhistorischen Hofmuseums, Vienna.
- Ber. Ak. Berlin.*—Sitzungsberichte der kais. preuss. Akademie der Wissenschaften, Berlin.
- Ber. Ak. München.*—Sitzungsberichte der kais. bayerischen Akademie der Wissenschaften, Munich.
- Ber. Ak. Wien.*—Sitzungsberichte der kais. Akademie der Wissenschaften, Vienna.
- Ber. chem. Ges.*—Berichte der deutschen chemischen Gesellschaft, Berlin.
- Boll. Com. Geol.*—Bolletino Comitato Geologico d' Italia, Rome.
- Bull. Cal. Acad. Sc.*—Bulletin of the California Academy of Science.
- Bull. Soc. Ch.*—Bulletin de la Société chimique, Paris.
- Bull. Soc. Min.*—Bulletin de la Société française de Minéralogie, Paris.
- Ch. News.*—Chemical News, London.
- C. R.*—Comptes Rendus de l'Académie des Sciences, Paris.
- Geol. För. Förh.*—Geologiska Förening i Stockholm, Förhandlingar.
- Jb. geol. Reichs.*—Jahrbuch der k. k. geologischen Reichsanstalt, Vienna.
- Jb. Min.*—Neues Jahrbuch für Mineralogie, etc.
- J. Phys.*—Journal de Physique, Paris.
- Min. Mag.*—Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain.
- Min. petr. Mitth.*—Mineralogische und petrographische Mittheilungen gesammelt von G. Tschermak, Vienna.
- Oefv. Ak. Stockh.*—Oefversigt af k. Vet. Akad. Förhandlingar, Stockholm.
- Wied. Ann.*—Annalen der Physik und der Chemie, Wiedemann, Leipzig.
- Zs. geol. Ges.*—Zeitschrift der deutschen geologischen Gesellschaft, Berlin.
- Zs. ges. Wiss.*—Zeitschrift für die gesammten Naturwissenschaften, Halle.
- Zs. Kr.*—Zeitschrift für Krystallographie, etc.

\* Only the more important publications, and those whose titles are contracted so as to need explanation, are here included.



## NECROLOGY OF MINERALOGISTS.

**WALTER FLIGHT.**—Born January 21, 1841; died November 4, 1885. From 1867 on, he was assistant in the mineral department of the British Museum. He was an active worker in chemical mineralogy, and was especially interested in meteorites. He published a number of papers on these subjects, among others a chapter on the History of Meteorites, which ran through a number of issues of the Geological Magazine.

**ARNOLD VON LASAULX.**—Born June 14, 1839; died January 25, 1886. He was privatdocent at the Bonn University in 1868, then professor (ausserordentlicher) of mineralogy at Breslau, later (1880) full professor at Kiel, and in the same year made professor at Bonn, where he spent the remainder of his life. He was an exceptionally active and successful worker in mineralogy and in petrography, and the list of his original papers in these and allied subjects is a long one. He was the author of two books, *Elemente der Petrographie* (1875) and *Einführung in die Gesteinslehre* (1885). He also extended his researches into the geological field, writing of earthquakes and volcanic phenomena.

**MARTIN WEBSKY.**—Born July 17, 1824; died November 27, 1886. He was a student of Weiss at Berlin in 1846, and later studied at Freiberg and Bonn. From 1850 to 1865 he was engaged in practical work in connection with the mining commission of Silesia, but during this time made many contributions to science. From 1865 to 1873 he lectured at the Breslau University, and after the death of Gustav Rose he was called to be his successor at Berlin, where he remained till his death. He stood conspicuously in the front rank of German mineralogists, and his contributions are many and of high grade; they are largely crystallographic, dealing with the description of crystallized minerals or with general theoretical problems of crystallography; he was also a successful analytical chemist. During his life at Berlin he devoted himself almost exclusively to the arrangement of the large collection of the university, and his activity in this direction, while perhaps an equal benefit to science in the end, was a great sacrifice from a personal point of view. His larger works include the well known "*Die Mineralspecies nach den für das specifische Gewicht derselben angenommenen und gefundenen Werthen*," which passed through several editions.

**CHARLES UPHAM SHEPARD.**—Born in 1804; died May 1, 1886. During the whole of his long life zealously devoted to mineralogy. He was graduated at Amherst College in 1824; in 1827 was assistant to Professor Silliman, at New Haven, in chemistry, mineralogy, and geology; after 1832 he divided his time between New Haven, Amherst, and Charleston; from 1845 to 1852 and 1861 to 1877 he was professor at Amherst, and in 1854 he was made professor of chemistry at Charleston, continuing his duties there till 1869, except as interrupted by the civil war. He was an active collector and student of minerals, and science owes to his keen eye the discovery of many new and interesting species, such as microlite, warwickite, danburite, as well as the development of many valuable localities. His large private collection, which became the property of Amherst College, was unfortunately destroyed by fire in 1880, but he continued to collect until his life ended. He was also active in collecting and describing meteorites, and brought together one of the largest collections in the country. In addition to many shorter papers, he was the author of a *Treatise on Mineralogy* in 1832, and in 1837 he published a report on the mineralogy and mineral products of Connecticut.

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## ZOOLOGY IN 1886.

By Prof. THEODORE GILL.

### INTRODUCTION.

The progress of zoology during the year 1886 has been in the same lines as during the preceding years, and with still greater concurrence. More and more attention is being paid to histology and embryology and perhaps at an undue expense to systematic zoology. Systematic zoology scientifically treated is simply the co-ordination of all facts derived from every branch of biology, anatomy, embryology, histology, and physiology; but there appears to be a disposition to relegate it to those who consider that its chief aim is to serve for identification of specimens, or to unduly generalize from a very few embryological facts. Such tendencies are hurtful to the welfare of zoology, but undoubtedly the tendencies in those directions will, in due time, be corrected.

As in the previous reports, the language of the original from which the abstract is compiled is generally followed as closely as the case will permit. It has however been found necessary to limit the abstract to the illustration of the prominent idea underlying the original memoir, and pass by the proofs and collateral arguments. At the same time, it has been often attempted to bring the new discovery into relation with the previous status of information respecting the group under consideration. As to the special discoveries recorded, they have been generally selected (1) on account of the modifications the forms considered may force on the system; or (2) for the reason that they are or have been deemed to be of high taxonomic importance; or (3) because the animals *per se* are of general interest; or, finally (4), because they are of special interest to the American naturalist. Of course, zoologists cultivating limited fields of research will find in omissions cause for censure, and may urge that discoveries of inferior importance have been noticed to the exclusion of those better entitled to it. It is freely admitted that this charge may even be justly made; but the limits assigned to the record have been much exceeded, and the recorder has studied the needs of the many rather than of the few. The summary is intended, not for the advanced scientific student, but for those who entertain a general interest in zoology or some of the better-known classes.

The bibliography which has been heretofore given with these reports is omitted from the present, as it has been thought that the space which would be occupied by it might be more profitably used for recording new discoveries. A partial bibliography is of little or no use to either the general reader or the investigator. The former rarely looks at it, and the latter seeks for information in the very full bibliographies or records of progress that are especially devoted to the subjects in question. For the current literature the "Zoologischer Anzeiger," published by W. Engelmann, of Leipzig, is available, and for the past years "The Zoological Record," hereafter to be published by the Zoological Society of London, the "Archiv für Naturgeschichte," published in Berlin, and the "Zoologischer Jahresbericht," also published in Berlin, are indispensable for the working naturalist. The compiler desires to make special acknowledgment for most material assistance to the Journal of the Royal Microscopical Society, whose abstracts of investigations have been freely drawn upon in the preparation of those for the present report.

#### SYNOPSIS OF ARRANGEMENT.

#### GENERAL ZOOLOGY.

- I. PROTOZOANS.
- II. PORIFERS. Sponges.
- III. CŒLENTERATES. Polyps; Aculephs.
- IV. ECHINODERMS. Pelmatozoans; Asterooids.
- V. WORMS. Platyhelminths; Nematelminths; Annelids.
- VI. ARTHROPODS. Crustaceans; Arachnids; Insects.
- VII. MOLLUSKS. Acephals; Pteropods; Gastropods; Cephalopods.
- VIII. PROTOCHORDATES. Tunicates.
- IX. VERTEBRATES. Fish like Vertebrates; Selachians; Fishes; Amphibians; Reptiles; Birds; Mammals.

#### GENERAL ZOOLOGY.

*Revivification of animals after desiccation.*—It has been repeatedly asserted, and with but little contradiction, that certain low types of the animal kingdom are capable of being revived after having been completely dried up or desiccated. Those who have questioned the statements have been comparatively unheeded. But the subject has been recently again investigated, practically, by Professor Zacharias, and it appears that the dissent expressed by the few is justified by the new experiments. Near Professor Zacharias's residence is a large granite block, which has lain there for two hundred years, having a cavity which holds from two to three liters of water that evaporates in from two to six days, according to the weather. In the water resulting from rain, which is held in this cavity, "a characteristic fauna was found to exist, notwithstanding the periodical desiccation." A peculiar variety of the rotifer named *Philodina roseola*, a tardigrade, and various protozoans

lived therein. "Observations made nearly fifty years ago indicate the presence at that date of a similar fauna, and there is every reason to believe that at least for a century similar forms have tenanted the cavity. Thus the fauna has persisted in spite of complete desiccation—thousands of times repeated. The problem is, How?"

In order to solve this problem, Professor Zacharias instituted a number of experiments, and found that the *Philodina* and tardigrade, "when allowed to dry, *invariably died*," but the ova were preserved from death by encystation. The persistence of the fauna is therefore not due to the survival of the adult animals, and their revivification on the reappearance of rain, but to the peculiar character of the eggs, which develop with the returning rain. In fine, Professor Zacharias has been led most decidedly to the conclusion that the desiccated forms in their mature condition, always die, while the eggs may frequently survive. These results are in accordance with those obtained by other experiments, for example the non-revivification of nematoid worms after desiccation, as was proved by Hallez. That which is true for animals is likewise applicable to plants. Thus, according to Professor Zacharias, the resting stage of *Hæmatococcus* and the zygospore stage of *Stephanosphaera* "explain the persistence of these algaoid forms in the pool." The conclusion is that "there is therefore probably no such thing as a real fauna and flora rediviva." (Biol. Centralbl., VI, pp. 230-235; J. R. M. S. (2), VI, pp. 799-800.)

*Minimum life temperatures.*—A series of experiments upon various animals has been made by Dr. H. von Ihering in extension of Professor Pouchet's researches on the resistance which animals may offer to cold. About two dozen worms, arthropods, and mollusks were made the subject of investigation. The results have been summarized in the following terms:

(1) "Lower animals become frozen at temperatures varying greatly in the different genera and species. The resistance varies with the actual body heat of the animal, with its size, structure, and protective covering, with the freezing point of the blood, etc."

(2) "The resistance usually increases with progressive development, but sometimes the adults are more sensitive than the young."

(3) "Nothing can be directly inferred from the geographical distribution."

(4) "Perfectly frozen animals are never revived."

Dr. von Ihering suggests a curve, with the degree and the duration of the temperature as co-ordinates. These two factors must be considered together. The absolute minimum is obviously the fatal temperature in unit time. He enumerates the various results, as exhibited by degeneration, cessation of certain functions, sleep, like paralysis, and death; and sums up his experiments in a tabular survey." (Zeitschr. f. Naturwiss., LIX pp. 183-214; J. R. M. S., 1887, VII, p. 52.)



*Physiology of the unstriated muscles of invertebrates.*—The physiology of the unstriated muscles of invertebrates has been investigated by Mr. H. D. Varigny, and, as a result, he came to the conclusion that “no essential difference exists between the unstriated and the striated muscles. The unstriated muscles, under certain conditions, even surpass the striated ones from a physiological point of view. In the invertebrata their rôle is an important one, for whilst remaining the active agents of the movements of nutrition, they become the agents of voluntary movements, and in contact with the nerves of voluntary motion derive such an energy and acquire such a perfect physiological development that they occupy in the functional hierarchy a superior rank to that of certain striated muscles, whilst the striated muscle is the most perfect and most developed contractile agent, and the one whose evolution is most advanced.” In fine, “there is no ground for dividing the physiology of muscles into two classes,” the differences existing in certain points being not essential, but of secondary moment only. (J. R. M. S. (2), v, p. 791.)

#### PROTOZOANS.

##### *General.*

*A new classification of protozoa.*—In an article entitled “Protozoa,” published in the Encyclopædia Britannica, Prof. E. Ray Lankester has given his views as to the best mode of grouping all the protozoa, in which he includes the mycetozoa. He admits no less than thirteen classes in the sub-kingdom, which he segregates under two groups or “grades.” The names and relations of the various classes will appear in the subjoined tabular enumeration :

#### PROTOZOA.

##### Grade A.—*Gymnomyxa.*

Section.	Class.
PROTEANA .....	I. <i>Proteomyxa</i> ( <i>Vampyrella</i> , <i>Protomyxa</i> , <i>Archerina</i> ).
PLASMODIATA .....	II. <i>Mycetozoa</i> ( <i>Eumycetozoa</i> ).
LOBOSA .....	III. <i>Lobosa</i> ( <i>Amæba</i> , <i>Arcella</i> ).
FILOSA .....	IV. <i>Labryrinthulidea</i> ( <i>Labryrinthula</i> , <i>Chlamydomyxa</i> ).
	V. <i>Heliozoa</i> ( <i>Actinophrys</i> ).
	VI. <i>Reticularia</i> ( <i>Gromia</i> , <i>Lituola</i> , <i>Astrorhiza</i> , <i>Globigerina</i> ).
	VII. <i>Radiolaria</i> . (Very numerous.)

##### Grade B.—*Corticata.*

LIPOSTOMA .....	I. <i>Sporozoa</i> ( <i>Gregarina</i> , <i>Coccidium</i> ).
STOMATOPHORA .....	II. <i>Flagellata</i> ( <i>Monas</i> , <i>Englena</i> , <i>Volvox</i> ).
	III. <i>Dinoflagellata</i> . ( <i>Prorocentrum</i> , <i>Ceratium</i> ).
	IV. <i>Rhynchoflagellata</i> . ( <i>Noctiluca</i> ).
	V. <i>Ciliata</i> . ( <i>Forticella</i> , <i>Paramæcium</i> , <i>Stentor</i> ).
	VI. <i>Acinetaria</i> . ( <i>A acineta</i> , <i>Deadrosoma</i> ).

## PORIFER.

*Sponges.*

*The nervous system in sponges.*—A specialized nervous system was formerly denied to the sponges, and has only been recognized within a comparatively few years. The last investigator of the subject has been Dr. R. von Lendenfeld. He has especially studied the muscular and nervous systems in the horny sponges, especially of Australia, and has formulated his conclusions and deductions therefrom. Premising that there are certain structures on the distal margin of the muscular membrane, he interprets them as follows: "The whole thickening, which is interrupted only here and there, consists of ganglion-cells, the nuclei of which are distinct in preparations, although their contours do not appear distinctly. The granular threads which are given off from these ganglia in a tangential direction, are nerves which establish the connection of the ganglia with more distant and at present still unknown structures."

From the description given, "it appears that the zone of sense cells runs along the upper margin of the muscular membrane, so that two bands of sense-cells are formed, bordering the tissue filling the groove at the surface."

Dr. von Lendenfeld believes that "this structure may be directly compared with the *annular nerves* of cycloneural medusæ (Eimer), and indicates that the sponges, being capable of a development similar to that of those cnidaria, were not probably so very different from them as we commonly suppose. It must, indeed, be admitted," says Dr. von Lendenfeld, "that, by *convergent* development, a resemblance may here have been produced which does not justify any phylogenetic conclusions, especially as these structures in the sponges are mesodermal, and not subepithelial as in the hydromedusæ."

In conclusion, it is said that "both the muscle and nerve cells are *mesodermal*. The *epithelia* of the sponges nowhere appear to be further developed after the fashion of the higher cœlenterata. Both endoderm and ectoderm always remain single." (A. and M. Nat. Hist. (5), XVII, pp. 372-377.)

## CŒLENTERATES.

*Polyps.*

*The coral of madrepores in relation to the soft parts.*—The comprehension of the relations of the hard coral to the soft parts of the animals which excrete it is rather difficult, and has been facilitated by Dr. G. von Koch in a special memoir upon the subject. The results are summarized in the Journal of the Royal Microscopical Society.

I. *The basal plate.* "This is excreted between the aboral terminal surface of the body and the substratum to which the skeleton is attached."

II. *The external plate or epitheca.* "This is a continuation of the basal plate, and yet more or less distinctly separable from it. It incloses the lateral body wall, but does not otherwise come into contact with the substratum."

III. *The internal plate or theca.* "This rises from the basal plate in the form of a circular ridge, usually parallel to the external plate, and generally ensheathed in an intruding fold of the body wall. There may be more than one internal plate."

IV. *The radial plates or septa.* "These are represented by numerous radial ridges, which ascend at right angles to the basal plate, and lie in radial folds of the body wall, which alternate with the parietes (mesenteries)."

In further explanation it is also noted:

(a) "The body wall always lies between the external and internal plates."

(b) "The parietes always lie between two radial plates, and the latter are, for some distance upwards, always separated by the internal plate into a peripheral and central portion."

(c) "The external plate is only clothed with tissue on its inner surface, but the internal plate on both surfaces."

(d) "Where the radial plates come into secondary contact with the external plate they penetrate the body wall."

With these postulates, "taken along with the fact that the skeleton is excreted by the ectoderm, a number of important conclusions may be deduced as to the origin, growth, and structure of the skeleton."

(1) "All parts of the skeleton are laid down as plates, and their growth is effected by the apposition of new particles on those already formed."

(2) "As to superficial increase, all parts of the skeleton are alike, but they vary in the mode of their increase in thickness. The thickening of the basal and external plates is only effected from one side, while that of the internal and radial plates may take place from both."

(3) "In the basal and external plates, the oldest portions are thus obviously on the outer side and the newer portions are inwards."

(4) "In the internal plate, the oldest portions are on either side, covered by successive strata, but the growth on either side may be disproportionate."

(5) "In the radial plates, the oldest portion is in the middle, and the subsequent depositions are symmetrically laid down on either side." (Morphol. Jahrb., XIII, pp. 154-160, 1 pl; J. R. M. S. (2), VI, pp. 805-806.)

### *Acalephs.*

*New form of fresh-water hydroids.*—Fresh-water hydroids are so few in number that any new species is noteworthy, and one has been described lately which is further interesting on account of some phases of

its life history. In 1871 Dr. Owsjannikow made known a peculiar parasite discovered in the ova of the sturgeon. This parasite proves now to be simply "a stage in the development of a free-living hydroid." It was made the subject of investigation by Dr. M. Ussow for two years, and the results of his researches have appeared in a preliminary notice. The form in question is related to the hydromedusæ in general, and has been named *Polypodium hydriforme*. The life history of the newly discovered hydromedusan is divisible into three stages, first, as a parasite in the eggs of the sturgeon, *Acipenser ruthenus*, wherein it exists as a cylindrical spirally twisted tube, with numerous lateral buds; then as "a free-living form, equipped with 24, 12, or 6 tentacles," and finally, "presumably as a sexual animal."

The first stage, or that of parasitism, is noteworthy. "The youngest specimen observed had the form of a cylindrical hollow tube, 15 to 17<sup>mm</sup> in length, 1½ to 2<sup>mm</sup> in thickness, and superficially beset with primary buds. The walls consist of single layers of ectoderm and endoderm, and of spindle-shaped (mesoderm) cells between. As this muscular layer develops, the body becomes spirally coiled in the longitudinal axis of the sturgeon's egg. The primitive buds become pear-shaped and the axial cavity of the organism is continued into each bud.

"Each of the primitive buds soon exhibits a gradually deepening furrow, dividing it into two pear-shaped bodies—the secondary buds. These are afterwards developed into free-living forms. The secondary buds come, in consequence of spiral twisting, to lie on one side of the whole organism ('stolon'), on that turned towards the chorion of the egg. The ectoderm cells next the central yolk are filled with yolk granules, which they have directly ingested. The yolk substance thus acquired penetrates through the endoderm into the cavity of the buds and accumulates as reserve material.

"The upper portion of the secondary bud exhibits a shallow furrow, and represents the aboral end of the future free-living form; and the furrow extending parallel to the long axis indicates the direction of a division which results in the halving of the free generation (or 'mothers').

"Tentacles are developed as invaginate tubes, and exhibit all the three layers. Of the twenty-four tentacles, eight are specially differentiated, as short, strong, terminally swollen 'Senktaster.' They exhibit numerous stinging cells developed in special cnidoblasts. The other sixteen are symmetrically arranged in pairs on both sides of the bud; they are thinner and much longer than the other eight. The tentacles are gradually and irregularly evaginated, the stolon begins to move, and eventually effects its liberation during spawning.

"After being in water for twenty-four hours or so the whole stolon falls into thirty-two pieces, representing the thirty-two buds; and this disruption occurs in a perfectly definite fashion. The buds have changed their form considerably since their first formation, and after liberation the old stalk and an adjacent portion of the stolon form a



movable proboscis, at the end of which a mouth-opening eventually appears. After the disruption of the stolon the individualized buds seem to be nourished at the expense of the yolk stored up in their cavities. These cavities, which extend even to the end of the tentacles, may be justly termed gastral cavities.

"The liberated mother bud (B), with twenty-four tentacles, is divided into two daughter forms ( $B^1$ ), with twelve each. These divide and give rise to two different forms,  $B^2$  and  $B^{2b}$ . The successive multiplication of the different generations is fully discussed and tabulated, and the three forms are described."

In brief, Dr. Ussow regards the *Polypodium* as "a hydroid organism, with a motile 'trophosome' (B) passing through various asexual generations before attaining the sexual (possibly medusoid) form. The planula of the latter migrates into the ovum" of the sturgeon, and "gradually develops into the stolon, with primary and secondary buds." (Morph. Jahrb., XII, pp. 137-153, 2 pl.; J. R. M. S. (2), VI, pp. 803-805.)

#### ECHINODERMS.

##### *Pelmatozoans.*

*Diversity among the blastoids.*—The pelmatozoans or crinoids, although comparatively rare at present, were formerly very abundant, and in the palæozoic seas represented by many diverse types. Among the most singular of these were the blastoids, which have been by most authors regarded as an order of the pelmatozoans, but recently Dr. P. Herbert Carpenter has contended that the group is separable from the crinoids as a class. A monograph of the group has been recently published by Mr. Robert Etheridge and Dr. P. Herbert Carpenter as a "catalogue of the blastoidea in the geological department of the British Museum." The authors maintain that "the blastoidea constitute a remarkably compact group, which is pretty clearly marked off from the other pelmatozoa." They find that the perforate lancet plate and the regular limitation of the hydrospires to the radial and the inter-radial plates, with their slits parallel to the ambulacra, are characters which are not as yet known to occur in either the crinoidea or the cystidea. The group thus distinguished is divided by Messrs. Etheridge and Carpenter into six families, which are segregated under two orders.

One order, the Regulares, includes "pedunculate blastoids with a symmetrical base, in which the radials and ambulacra are all equal and similar." This group includes four families: (1) *Pentremitidæ*, with three genera, the chief of which is the genus so well known to American paleontologists under the name *Pentremites*, and (2) *Troostoblastidæ*, a new family, with three genera, two of which have been established by American naturalists; (3) *Nucleoblastidæ*, also a new family, including four genera, one of which is made the type of the subfamily *Elæacrinidæ*, while the other three belong to a second subfamily, *Schizoblastidæ*; (4)

*Granatoblastidæ*, with two genera; (5) *Codasteridæ*, with four genera, two of which belong to the special subfamily *Phenoschismidæ*, and the other two to another named *Cryptoschismidæ*.

The second order of blastoidea is named Irregulares, and is restricted to "unstalked blastoids, in which one ambulacrum, and the corresponding radial are different from their fellows," and the "base usually unsymmetrical." This group includes only one family, long ago called *Astrocrinidæ*, but amended by Messrs. Etheridge and Carpenter, and made to include three genera.

According to Messrs. Etheridge and Carpenter, the true blastoids do not appear previous to the Upper Silurian period, and they appear to have become extinct long before the close of the Carboniferous, no traces of blastoids from the Lower Carboniferous (or calciferous sandstone series), much less from any of the marine bands of the coal measures, being recognized.

All the known blastoids of "the Upper Silurian period are confined to American strata, and represent the families Troostoblastidæ and Codasteridæ."

In the Devonian period "all the families are represented. The Silurian Troostoblastidæ, however, do not appear in the American Devonian rocks; but they are well represented in Europe, although the Devonian blastoids generally are slightly more numerous both in genera and species in America than in Europe. In Europe the great center of blastoid life in Devonian times appears to have been in the north of Spain, whilst in the British isles there is but the scantiest evidence of their presence in the rocks of that period." (Etheridge and Carpenter, *op. cit.*; An. and Mag. Nat. Hist. (5), XVIII, pp. 412-417.)

### *Asterioids.*

*Organization of star-fishes.*—In the course of investigation of a new incubating star-fish from Cape Horn, to which the name *Asterias hyadesi* has been given, Prof. Edmond Perrier has described a peculiar organ, and deduced certain conclusions in respect to the taxonomy of the echinoderms:

"On the wall of the sacciform canal which surrounds the hydrophoral tube there is attached a problematic organ, which is prolonged beyond the sacciform canal, in such a way as to form two organs connected with the intestine, and giving off two lateral branches, which are in direct relation with the genital glands. This problematic organ, which has lately been called the chromatogenous organ by Hamann, has in young *Asterias hyadesi* the form of a lateral conical prolongation of the peritoneal membrane of the digestive sac, and it contains a large number of vitelline bodies identical with those of the wall of the sac. The lobes of its surface are continuous with the trabeculæ which form the living basis of the skeleton of the star fish, and it dilates at its external surface into membranes, which envelop the hydrophoral tube. This collateral organ

of the tube is then not a heart, but the site of the production of elements, some of which, becoming free, form the corpuscles of the general cavity. The canaliculi of the madreporite are due to nothing more than the folding of the walls of the vibratile infundibulum, by which the hydrophoral tube opens to the exterior. Prof. Perrier is convinced that the tube communicates at the point where it unites with the apex of the funnel with the cavity of the sacciform canal. If the canaliculi of the madreporic plate only lead into the hydrophoral tube or its upper expansion, the tube itself opens into the sacciform canal laterally, and sea water can thus pass into the lacunar spaces, which Hamann considers as a schizocoel, into the subambulacral cavities, and into the general cavity."

Professor Perrier concludes that in star-fishes, "as in echinids and comatulids, sea water plays an important physiological part, but its course is not regulated by as complicated a system of irrigating canals; from this it is deduced that the echinoderms are divisible into two great groups. One of these contains cystoidea, blastoidea, stelle-ridæ, and ophiurida, and the other crinoids, echinoids, and holothurians, and it is added that in this phylum, as in cœlenterata and sponges, the penetration of water is a general phenomenon, while it is rare in worms, arthropods, mollusks, and vertebrates. It is therefore concluded that the old division of De Blainville, with certain modifications, may be retained, and that all animals may be divided into three great groups, Protozoa, Phytozoa, and Artizoa." (*Comptes Rendus Acad. Sc.*, cii, pp. 1146-1148; *J. R. M. S.* (2), vi, pp. 624, 625.)

#### WORMS.

##### *General.*

*Resemblances and differences of the nervous system of worms.*—In connection with the observations on the development of the nemertean worm named *Monopora vivipora*, Prof. W. Salensky has considered the homologies of certain parts, and especially of the nervous system and proboscis of the nemertean, rhabdocœlous, and annelidan worms, and gives his views in a tabulated form, contrasting the various groups.

The nervous system of the nemertines is contrasted with that of the annelids in one table:

Nemertines.	Annelids.
Cephalic ganglia.	Cephalic ganglia.
Ventral commissure.	Dorsal commissure.
Dorsal commissure.	O.
Lateral nerves.	Circumœsophageal commissure.
O.	Ventral ganglionic chain.

The proboscis and its adjuncts in the nemertines, as compared with the parts of the rhabdocœles, is explained in the following terms :

Rhabdocœla.	Nemertinea.
Pouch of proboscis.	{ Vestibule of proboscis.
Epithelium of proboscis.	
Internal layer of muscular investment.	
External layer of muscular investment.	
Radial muscles of muscular investment.	{ Epithelium of proboscis. Muscular layer of proboscis. Walls of the sheath of proboscis.
	Muscular band.

(J. R. M. S. (2), v, pp. 811–813.)

#### *Conodonts.*

*Nature of conodonts.*—The peculiar small tooth-like organisms found in paleozoic rocks, and which have been named conodonts, have been again subjected to investigation by K. von Zittel and J. V. Rohon. These little bodies have been regarded, at least by some old authors, as the remains of vertebrates related to the myzonts or lampreys and hags. It is not probable that this view is now entertained by any competent to have an opinion, but the nature of conodonts is still undetermined. The authors just referred to conclude that the structures in question are neither related to the dentine teeth of true fishes or selachians, the horny teeth of cyclostomes or marsipobranchiates, the teeth of mollusks, the beaks of cephalopods, nor the spines of crustaceans, but do in form and structure closely resemble the oral armature of annelids or geophyreans. This view has been previously enunciated, but the corroborative testimony afforded by independent observers is of interest. It is well added that if the view thus entertained be true, “there must have been in paleozoic times an immense number of very varied worm forms.” (S.-B. k.-bayer. Akad. Wiss. München, 1886, pp. 108–136, 2 pl.; J. R. M. S. (2), VI, p. 984.)

#### *Platyhelminths.*

*Origin of the nervous system of the nemertine worms.*—The morphology of the nemertine worms has been investigated by Prof. A. A. W. Hübner. The information respecting the origination and development of the nervous system is of special interest. “No portion of the central nervous system” of the chief species examined, *Lineus obscurus*, “takes its origin from either primary or secondary epiblast, but the whole nervous system is of mesoblastic origin. At first the archenteron communicates with the enteron by a wide blastophore, but later on the cavity of that portion of the intestine which grows backwards is closed anteriorly, and in front of this another portion of the embryonic intestine constantly remains in open communication with the exterior; the



anterior foregut opens by a crescentic slit, and this would seem to become the mouth of the adult; in other words, there is no epiblastic stomodæum; part of the foregut becomes the œsophagus, and the rest appears to be converted into the nephridal system. The nephridia seem to long remain in a more or less embryonic phase, but their history is very difficult to make out, and is as yet only incompletely known.

"The mesoblast cells, once freely moving about in the blastocœl, soon accumulate against the inner surface of the plates of secondary epiblast, and the mass increases in size. The process of differentiation leads to the appearance of muscle and nerve cells at a very early date; the mesoblast cells form a massive group in the prostomium, and a comparatively thin cell-sheet in the rest of the body.

"Unexpected as is the mesoblastic origin of the nervous system, there appears to be no doubt about it. Hubrecht, indeed, thinks that Salensky's figures of *Amphiporus viviparus* point to the mesoblastic origin of the nervous system in that animal rather than the mode of origin approved by Salensky." (Quart. Journ. Micr. Soc., xxvi, pp. 417-448, 1 pl.; J. R. M. S. (2), vi, 6, pp. 614, 615.)

*Cephalic pits of nemertines.*—On the surface of the heads of nemertine worms are developed certain pits whose functions and nature have been long unknown. It has been recently suggested by M. Rémy de Saint Loup that the cephalic pits may be "strictly compared to the essential forms of the segmental organs" of the leeches, from which they only vary in structure and function" (sic!) It is also suggested that "they may serve as auditory organs, as an irrigating and respiratory apparatus, or as a head-kidney." (Comptes Rendus Acad. Sc., cii, pp. 1576-1578; J. R. M. S. (2), vi, p. 797.)

#### *Nematelminths.*

*Relations of hair-worms.*—The elongated hair-like animals which are generally believed by common people to be vivified horse-hairs—the *Gordiidae* of naturalists—have been investigated by Prof. F. Vejdovsky. As the result of his investigation the professor concluded that "although the external form of the body appears to ally the *Gordiidae* with the nematoid worms, the rest of their organization is so different that they ought to be separated from that class of nemotohelminths, and brought into closer relations with the Annulata; the presence of a true cœlom and of mesenteries, as well as the highly developed central nervous system and the segmental arrangement of their glands, demand this change." The absence of the enteric fibrous layer to the enteric canal, in which the *Gordiidae* resemble the nematoid worms, "may be explained by the fact that the *Gordiidae* take in no food during their free-living stages, while the conditions of these parts are unknown in the younger and parasitic stages. As in the Annulata, the mesenteries arise by the differentiation of the epithelial layer of the cœlom."

As to the nervous system, "both developmentally and histologically, the ventral cord agrees" with that of the annulates. Although the peripheral system of the Gordiids is very different from that of the Annulata, "it is not difficult to find homologies between the two." Other resemblances are found by Dr. Vejdovsky in "the structure of the body wall, the hypodermis of the Encytræidæ being exactly like that of the Gordiidæ; *Polygordius*, again, has, like *Gordius* (and the nematoids), no circular muscular layer." Also the structure of the muscular tissue is of the annulate and not of the nematoid types. The characteristics of the Gordiids, thus briefly hinted at, are sufficient, Professor Vejdovsky thinks, to entitle the Gordiids to be isolated as an independent order, and for this the name of Nematomorpha is proposed. (*Zeitschr. f. wiss. Zool.*, XLIII, pp. 369-433, 2 pl.; J. R. M. S. (2), VI, p. 988.)

### *Myzostomids.*

*The relations of the myzostomids.*—The curious parasites of the crinoids known as *myzostomids*, and having some superficial resemblance to mites, have been examined as to their anatomy and histology by Mr. F. Nansen. Various peculiarities of the nervous system have been described as well as characteristic features of other parts, but for a knowledge of these reference must be made to the original memoir or to a full abstract in the *Journal of the Royal Microscopic Society*. It will be sufficient here to summarize the results of the investigations upon complemental males and the systematic position of the group.

Complemental males were found in three species, *M. giganteum*, *M. gigas*, and *M. carpenteri*. Such males are "similar in structure to the hermaphrodites, except that where the latter have ovaries, the males have tubes with slightly developed cells, so that they have a certain resemblance to young ovaries; the dorsal oviduct (uterus) is feebly, but the lateral oviducts are well developed. The author disagrees with Beard as to the secondary origin of the hermaphroditism of Myzostomida, inasmuch as the dioecious species are the most parasitic, and the rudiments of testes in *M. cysticolum* appear to be rather remnants of an androgynous stage than budding developments of male organs."

The systematic relations of the group, according to our author, are rather with the chætopods, from which, nevertheless, they are sufficiently distinct. They also show "a tendency towards certain arachnids (Linguatulida, Tardigrada, and perhaps Pycnogonida) and crustaceans." On the whole, however, it is believed by Mr. Nansen that the group is derived "from the Trochophora, and, among archiannelids, are related to Histriodrillus." (*Bidrag til Myzostomernes Anatomi og Histologi*, Bergen, 1885; J. R. M. S. (2), VI, pp. 619-621.)

## ARTHROPODS.

*Crustaceans.*

*The land isopod crustaceans.*—The isopod crustaceans found upon the land, and some of which are known under the name of pill-bugs and sow-bugs among the English-speaking peoples, have been studied by Dr. Gustav Budde-Lund, and it seems that the species are quite numerous. Four families have been admitted by Dr. Budde-Lund for the species, and are named by him Onisci, Ligia, Tylides, and Syspastidæ. By far the best represented of these families is that of the Onisci, or, as it is more generally called, the Oniscidæ. Fourteen genera are recognized for the species, and these genera are segregated into two sections, (1) the Armadilloidea, including eight genera, and (2) the Oniscoidea, embracing six genera, and in addition two or three genera unknown to the author have been noticed. The largest of the genera is *Porcellio*, to which one hundred and four species are referred, of which eighty-two or eighty-four are new, and to this succeed, so far as numbers are concerned, *Oniscus*, with twenty-six or twenty-eight new species, and *Armadillo*, with twenty-seven. The family of the Ligia or Ligiidæ has eight genera and thirty-three well-determined and fourteen doubtful species; that of the Tylides or Tylidæ, a single genus, with twelve species; that of the Syspastidæ includes only a single species. The total number of species described as members of the four families is "four hundred and four or four hundred and ten, of which three hundred and twelve or three hundred and sixteen are good species, and ninety-two or ninety-four are species unknown to the author, or reputed species. The total number of genera is thirty-six, or (if some be accounted subgenera) twenty-five. (Crustacea isopoda terrestria per familias et genera et species descripta a Gustavo Budde-Lund, Havniæ, 1885; noticed in Ann. and Mag. Nat. Hist. (5), xvii, pp. 81-84.)

*Arachnids.*

*Ant-like spiders.*—The ants are mimicked by representations of various groups of spiders as well as of other orders of insects. Prof. T. Bertkau has called attention to a number of such cases. Very frequently the ant-like appearance is entirely superficial and disappears on close examination. Numerous hemipterous insects, and especially the *Alydus calcaratus*, exemplify this kind of mimicry. The resemblance in the case of *Alydus* is, however, due chiefly to the median constriction of the body, the dark brown color, similarity of size, and the slight difference of development between the head and tail. In the spiders the resemblance is often quite close. Among the Attidæ the cephalothorax and the posterior part of the body are often proximately equal. In the Drassidæ "there are frequent instances of ant mimicry, as, for instance, in the genera *Phrurolithus*, and especially *Micaria*." Among

the Theridiidæ a beautiful instance of mimicry is furnished by the appropriately named *Formicina mutinensis*. On elm trees resorted to by ants of the genera *Lasius* and *Formica*, an ant-like spider named *Lascæla procox* occurs, but "as the mimicry is exhibited only by the developed males, which eat but little, the resemblance must be" in this case "purely protective."

The spider families *Thomisidæ* and *Epeiridæ* do not furnish any examples of such mimicry, and indeed, according to Professor Bertkau, in those spiders "ant mimicry seems impossible." (Verhandl. naturh. Verein Rheinlands, XLIII, pp. 66-69; J. R. M. S. (2), VI, p. 977.)

### *Insects.*

*Entomogenous fungi*.—Insects are not rare in which appendages of a cottony or silky structure, or rather reminding one of such, and borne on long peduncles, are seen growing through the joints of the body. These appendages are really fungi of various kinds. A genus of large size, and which, to a considerable extent, flourishes upon insects of various kinds, is the genus *Cordyceps*. Forty-seven species of this genus have been recorded by Professor Saccardo, of which twenty-three, or about 50 per cent., are found in larvæ, and sixteen, or about 33 per cent., in perfect insects. In fact, the fungus is not so common in perfect insects as in the larvæ. Of the sixteen species occurring on the imago or perfect insect noticed by Saccardo, three are noted as having been found upon various species of ants; they are (1) *Cordyceps unilateralis*, found on the *Atta cephalota* of Brazil; (2) *Cordyceps australis* on *Pachycondyla striata*, also of Brazil; and, (3) *Cordyceps myrmecophila* on *Myrmica rufa* (as well as on an ichneumon and a beetle), in North America, Europe, Ceylon, and Borneo. The *Cordyceps unilateralis* has been also found infesting another ant of Brazil, as well as two species collected by Mr. A. R. Wallace at a village on the island of Celebes. The Brazilian ant is *Formica sexguttata*. Recently a new formicogenous species of the genus, named *Cordyceps lloydii*, has been described by Mr. William Fawcett; the ant on which the new *Cordyceps* was found has the appearance of being attacked by the fungus while it was alive. The growth of the fine threads of the mycelium through the body would in time kill it. (A. & M. Nat. Hist. (5), XVIII, pp. 316-318.)

*Luminous beetles*.—Among the elateroid beetles are some conspicuous for the light which emanates from their bodies. These luminous elaterids, according to Mr. R. Dubois, are the animals "which best lend themselves to physiological analysis," and consequently facts bearing upon the general theory of biological luminosity may be gathered from them. The luminous elaterids are mostly found between 30° south and 30° north latitude and between 40° and 180° of longitude. "The emission of light is intimately connected with an important physiological function, but in some rare cases there is no luminosity. The posi-



tion, form, and powers of the luminous organs vary slightly in different species, and a few have no such organs. One of the most brilliant is *Pyrophorus noctilucus*, which has been especially studied by Mr. Dubois." A preliminary anatomical examination compelled Mr. Dubois to make certain corrections of statements previously current in regard to the situation of the stigmata, the distribution of the tracheæ, and the relations of the nervous system to the light producing organs.

The luminiferous organs are "composed of a special adipose tissue and of certain accessory organs. Histochemical investigation revealed the presence of a body which presents the character of guanine. Intense histolysis takes place in the photogenous adipose tissue, the changes being provoked or stimulated by the penetration of blood into the luminous organs; the histolytic process is accompanied by the formation within the photogenic cell of a vast number of small crystalline agglomerations of special optic properties, and especially remarkable for their double refraction."

The blood, however, is "not indispensable for the production of light, for the ovum is luminous even before segmentation, and the adipose photogenic cell, when isolated, exhibits the same property: these facts point to a similarity between the substance of the adipose body and that of the vitellus. The larvæ, hitherto unknown, have been by the author found to resemble those of other Elateridæ, but are luminous. "At first they have but a single luminous organ, but this extends over all the segments, and is localized at the points where histolysis is most active. In the adult insect there are three luminous spots, which are so placed as to aid walking, swimming, and flying in obscurity. The muscles of the luminous organs regulate the supply of blood to the photogenic organs, and so have an indirect action on the production of light; the nerves act through the muscles; the photosensitive reflex action has its seat in the cerebroid ganglia; centrifugal irritation of the ganglia produces the appearance of light, but this is not the case with centripetal stimulation. Respiration has only an indirect influence on the photogenic function, and this by maintaining the vital conditions of the blood and of the tissues; the nature of the food has no influence on the production of animal light. The cell (the non-segmented ovum, or the adipose cell) prepares the photogenic principles under the influence of nutrition, but the light is not the direct result of the proper activity of the organized and living anatomical element. When the structure of this anatomical element and its vitality are destroyed, the luminous phenomenon can still be produced by a physico-chemical action, similar to that which converts glycogen into sugar in the liver. Though the luminous organs of *Pyrophorus* are the most remarkable known to us, the organic expense is almost insignificant as compared with the effect produced; so, too, the loss of energy is very slight, whereas in artificial light it may be as much as 98 per cent."

The causes of "the admirable economic superiority" are analyzed and the author summarizes them as follows:

(1) "There are a number of chemical rays in this light, as may be shown by photography, but there is only a small proportion of them; the result must be ascribed to the existence of a fluorescent substance, which has been discovered in the blood of *Pyrophorus*, and which, by penetrating into the organ, gives it the special and brilliant character which distinguishes the light. The greater number of the chemical rays are transformed into very brilliant fluorescent rays of a medium wave length."

(2) "Optic analysis shows that the light is in great part composed of rays similar to those which are found at those points of the spectrum where experience has fixed the maximum of illuminating intensity."

(3) "There is no loss by heat radiation; the amount of heat given off, even at the time of greatest activity, is infinitesimal."

(4) "There is no reason for supposing that there is any conversion of energy into electricity."

(5) "This marvellous light is physiological because it is of vital origin, and because no other source is as well adapted to the wants of the organ of vision in the animal series." (Bull. Soc. Zool. France, XI, pp. 1-275, 9 pl.; J. R. M. S. (2), VI, pp. 595-597.)

*Odoriferous apparatus of the bed-bug.*—A large section of insects of the great order of Hemiptera are notorious for the unpleasant odors which emanate from their bodies, and not the least notorious is the form too well known to many under the name of bed-bug. The allies of the bed-bug have mostly wings. In the early or larval condition they have three abdominal and dorsal glands, and these persist until the last change of skin; they then become atrophied; when their wings appear, a thoracic and sternal glandular apparatus becomes developed. Those species "which suck sap are therefore provided with two systems of organs of secretion, situated in two opposite parts of the body, according as they are in the state of larva or pupa, or in the adult state."

"The presence, at different ages," says Mr. Künckel, "in the same insect, of glands having different anatomical relations, but possessing the same physiological attributes, is a fact which leads us to interesting deductions." We need not follow Mr. Künckel in these deductions, but simply record his observations on the bed bug. "Some naturalists," he remarks, "have thought that these creatures, when adult, represented the pupa state of other Hemiptera, and that the number of moults justified their opinion;" but according to Mr. Künckel, "the disappearance of the larval and pupal odoriferous glands coincides with the appearance of new odoriferous glands, the exclusive appanage of the adult Hemiptera; then the *Cimices* capable of reproduction and regarded as pupæ are not able after another moult to acquire wings; they are creatures which have attained the last term of their development." In fine,

according to Mr. Künckel, "the bed-bug, from the time of its hatching, in the state of larva and pupa, possesses three dorsal, abdominal, odoriferous glands, which disappear in the last moult, and are replaced in the adult state by a metathoracic, sternal, glandular apparatus. The presence of this apparatus is a criterion which enables us to prove that the *Cimex* has completed its evolution." (C. R., 1886, July 5, p. 81; Ann. and Mag. Nat. Hist. (5), XVIII, pp. 167-168.)

*Odoriferous apparatus of butterflies.*—The nature of the production of the various kinds of odors emitted by butterflies has been investigated and reported upon by Dr. E. Haase. Some odors are common to both sexes, while others are restricted to one or the other.

Those odors which are common to both of the sexes are of two categories, (1) "those which depend on some definite ethereal oil resulting from the food of the caterpillar," and (2) those which are of use in the protection of the animal, and emitted against its enemies.

The odors which are restricted to one of the sexes are "the various attracting and captivating smells of sexually mature males and females." These are especially manifested by the Bombycidae, containing some of the large moths, when the odor of the female attracts males from a great distance. Without their olfactory antennæ, it is believed, the males would be unable to find the females, and it is to be noted that "the males are odoriferous only when the female is capable of flight." The fragrance is "variously disposed, on scales of the wings, in thoracic pouches, in pouches on the posterior wings, etc. There are small odoriferous scales, usually occurring. They are generally protected, often associated with tufts of hair, which diffuse fragrance." The modifications of the odoriferous apparatus, exemplified in various German and tropical Lepidoptera, are noticed. (S.-B. naturf. Gesell. Isis, 1886, pp. 9, 10; J. R. M. S. (2), VI, pp. 969-970.)

#### MOLLUSKS.

##### *Acephals.*

*Poison of the edible mussel.*—The poisonous qualities of the common table mussel have been investigated by Dr. G. Baumert and Mr. E. Salkowski. The poison of the mussel was found by Salkowski in a cold alcoholic extract of the substance of the mollusk; watery extracts were also poisonous; these results were obtained by physiological experiments.

Chemical investigations were undertaken by Mr. Brieger, and it was shown that "there was a non-poisonous base, the specific mussel poison, an extremely poisonous substance which produced a copious flow of saliva and diarrhoea, but was not mortal, and a decomposition product of poisonous properties. The mussel poison appears to belong to the group of ptomaines, and is therefore a decomposition product of the flesh of the mussel. Dr. Schneidemühl is of opinion that the liver is the

seat of the poison, therein agreeing with Salkowski." (Zeitschr. f. Naturwiss., LIX, pp. 60-62; J. R. M. S. (2), VI, p. 587.)

### *Pteropods.*

*The food of pteropods.*—In a memoir on the systematic relations and biology of pteropods, Dr. J. E. V. Boas, of Copenhagen, has given details as to the food of seven species of pteropods, *i. e.*, *Limacina balea*, *L. helicina*, *Cleodora pyramidata*, *Hyalva trispinosa*, *Cuvierina columnella*, and an undetermined species of *Tiedmannia*. The food of these species varies according to the temperature of the water in which the species abound; those found in warm water had a specially rich and varied assortment of food. The *Globigerinæ* and *Acanthometræ*, and other radiolarians contributed to the food of most of the species. Infusorians were also largely partaken of, and especially a goodly portion of Tintinnoidea were found in almost all of the species; cocospheres and diatoms were also found in the food of several species. Very few animals or plants of a higher grade of organization formed any portion of the contents of the stomach. Only in two species were there found any remains of crustaceans; in one fragments of a copepod being found, and in another remains of an undetermined crustacean. (Zool. Jahrbücher, I, pp. 311-340.)

*Families of gymnosomatous pteropods.*—A remarkable gymnosomatous pteropod was obtained by the U. S. Fish Commission steamer *Albatross* off the coast of Carolina, in north latitude  $38^{\circ} 10'$ , west longitude  $74^{\circ} 15'$ . It measured 8<sup>mm</sup> in length, and has been made known by Mr. Paul Pelsener under the name *Notobranchæa macdonaldii*. It has the "body contracted behind, presenting only a posterior branchia formed by three crests (one dorsal and two lateral), of which the dorsal one alone is fringed;" the anterior and posterior lobes of the foot are long and narrow and the former free for the posterior two-thirds. These characters contrast in one or other respects with all the other representatives of the suborder, and have been regarded by Mr. Pelsener as of family value. The family is named *Notobranchæidæ*.

The other families of *Gymnosomota* are as follows:

In the *Pneumodermatidæ*, the visceral envelope presents a specialized branchial apparatus, and acetabuliferous buccal appendages are developed.

In the *Clionopsidæ*, the visceral envelope presents a specialized branchial apparatus, but no acetabuliferous buccal appendages are developed.

In the *Clionidæ*, the visceral envelope presents no special branchial apparatus, and the body is elongated and pointed behind.

In the *Halopsychidæ*, the visceral envelope also presents no special branchial apparatus, but the body is ovoid and rounded behind. (Ann. and Mag. Nat. Hist. (5), XIX, pp. 79, 80.)



*Gasteropods.*

*Nervous system of ctenobranchiate gasteropods.*—In a memoir upon the nervous system of the scutibranchiate gasteropods, Mr. E. L. Bouvier has directed special attention to the character of the proboscoidal commissure. In a memoir upon the nervous system of the ctenobranchiate gasteropods he had maintained that the proboscoidal commissure disappears, but that "there is another connective which is very characteristic. It is that which more or less distinctly connects the right commissural ganglion with the subintestinal. This connective results from the anastomosis of the right pallial nerves, which issue from the right commissural and from the sub-intestinal ganglia. The author enumerates various forms in which this arrangement is found. In the Cerithiidae the conversion of the anastomosis into a connective may be studied step by step. When once formed it varies very greatly in dimensions. On the left hand side the pallial nerve always retains its origin in the commissural ganglion, except in *Ampullaria*, when it is converted into a connective, going from the left commissural to the supra-intestinal ganglion." (*Comptes Rendus Acad. Sc. Paris*, CIII, pp. 938, 939; J. R. M. S. (2), 1887, p. 60.)

*Nervous system of scutibranchiate gasteropods.*—The nervous system of various dioecious gasteropods of the groups Scutibranchiata, Aspidobranchiata, and Cyclobranchiata has been investigated by Mr. E. L. Bouvier. He found that a number of them agree in certain characters and consequently proposed to combine them under a general heading as scutibranchs. The common characters are stated to be as follows:

(1) "The cerebroid commissure is very long, so that the ganglia are set at the sides of the digestive tube; these ganglia are produced forwards and below to form a strong ganglionic projection, which is united with that of the opposite side by a subœsophageal commissure; this cord is called the proboscoidal commissure."

(2) "The stomato-gastric system arises from the inferior point of the proboscoidal projection and forms a loop; the two sympathetic ganglia are generally widely separated."

(3) "The pedal ganglia are well developed and form pedal cords, while the principal nerves, with which they are continuous, are almost always united by transverse commissures."

(4) "The pallial ganglia are always more or less intimately connected with the pedal ganglia."

Of these characters, the first two are regarded as being "primitive in nature," and the presence of the proboscoidal commissure, described by Lacaze Duthiers in *Haliotis tuberculata*, is maintained in contradiction of the statements of Bela Haller, who denied its existence. Other statements of Haller are likewise traversed by Mr. Bouvier. (*Comptes Rendus Acad. Sc.*, CII, pp. 1177-1180; J. R. M. S. (2), VI, pp. 584, 585.)

*Morphology of the ampullariids.*—The ampullariids or apple-snails are especially interesting on account of the union of a lung-like breathing apparatus with true branchiæ, and this peculiarity is combined with some salient differences from other gasteropods in the development of various parts of the body. The shell varies in different forms, being generally subglobose, but in some discoid and like a *Planorbis*, and in others turreted and very much like the shell of the typical viviparids. The anatomy of such a type must therefore be always of interest. It has been investigated again by Mr. E. L. Bouvier. An examination of the nervous system has shown that it is “both chiasmoseous and zygoneurous.” The “penis is an appendage of the mantle, and is innervated by the right pallial nerve,” an interesting fact, as it is “a very rare if not unique arrangement.” The epipodium is supplied by the commissural ganglia, and not, as had been previously stated, by the pedal; it is consequently a derivative from the mantle, and it becomes thus manifest that “the so-called epipodial structures are not all of the same morphological significance, for some are appendages of the foot, and others of the mantle or body wall.”

As in the ctenobranchiates or gasteropods bearing pectinated gills generally, “the gill and false gill are innervated by the supra-intestinal branch of the commissure,” and, on account of this mode of supply, “it may be concluded that in *Ampullaria* and all other ctenobranchs, the gills are the homologues of the left gill and so-called olfactory organ of the zeugobranchs,” and not of the right gill of the latter, as most anatomists have considered. Mr. Bouvier concludes that the systematic relations of the ampullariids are with the zygoneurous tænioglossates, and that the family approaches most nearly to the calyptræids. Whether this view will be generally accepted is perhaps doubtful. (C. R. Acad. Sc. Paris, CIII, pp. 162–165; J. R. M. S. (2), VI, pp. 949, 950.)

### *Cephalopods.*

*Relations of the cephalopods.*—In the discussion of the morphology and relationship of the cephalopods, Prof. C. Grobben contends that those mollusks are most closely related to the scaphopods or dentaliids, and not to the pteropods, as has been thought by many to be the case. In his latest communication, he has devoted special attention to the innervation of the arms as well as their development, and to a comparison of the type with *Dentalium*.

In Professor Grobben's opinion, the arms certainly can not be considered as modifications of the anterior portion of the foot, as is abundantly proved by the nerve supply. (1) “The cerebral ganglion is continued downwards round the œsophagus,” and “a portion of the subœsophagus, more apparently belonging to the pedal ganglion, really belongs to the cerebral.” (2) “Of the nerve fibers supplying the arms, many undoubtedly terminate in the downward-directed portions of the brain, but others may be traced through the anterior and posterior lateral commissures

into the posterior basal lobes of the cerebral ganglion." The arm nerves and brachial ganglion therefore owe their origin, "not to the pedal but to the cerebral ganglion," and von Ihering's suggestion that "the brachial was really a separate portion of the cerebral ganglion," is thus corroborated.

The comparison is especially interesting between the structure of *Nautilus* and *Sepia* on the one hand and *Dentalium* on the other. The body of *Dentalium* is so oriented that "of the two mantle apertures, the larger, through which the foot projects, is turned forward and downward, while the narrower lies at the apical pole of the body. The mantle cavity occurs at the posterior side of the body." In connection with the superior mantle aperture in *Dentalium*, considerable space is devoted to the discussion of the origin and development of the mantle cavity and cleft. Finally, it is contended that the arms of cephalopods are homologous with and derived from the cirri of the scaphopod or dentalioid gasteropods, and special comparison is made with the tentacles of *Nautilus*, each tentacle of the nautilus being regarded as homologous with an arm of a dibranchiate cephalopod. These conclusions will doubtless be dissented from by not a few morphologists. (Arbeit. zool. Inst. Univ. Wien, VII, pp. 61-82; J. R. M. S. (2), VI, pp. 950, 951.)

*Living cephalopods.*—The recent cephalopods have been investigated by Mr. William Hoyle in connection with the specimens obtained by the *Challenger* expedition, and a monograph of those acquired by the great expedition, as well as "a catalogue of recent cephalopoda," has been published.

Mr. Hoyle admits, in his catalogue, "three hundred and eighty-eight species, which are disposed in sixty-eight genera, and these into fourteen families." Of these species at least sixty to seventy "have been inadequately characterized, so that it is unlikely that they could be recognized from the published descriptions, and the same is true of several of the genera; hence it may be said in round numbers that we are acquainted with the fifty or sixty recent genera, containing three hundred species. It is worthy of remark that twenty-nine, or half the genera, contain only one species each, while nearly one-half the species one hundred and seventy, belong to the three genera *Octopus*, *Sepia*, and *Loligo*."

The species have been considered by Hoyle with reference to their distribution and have been referred to three primary groups: (1) the pelagic; (2) the abyssal; and (3) the littoral. Those of the first two categories have been further associated together as "oceanic" species, and have been distributed in three groups "corresponding to the Atlantic, Pacific, and Indian (including the Southern) Oceans, rather from convenience than from a belief that such a division is natural, although the great majority are confined to one area. The chief factor limiting their spread," according to Mr. Hoyle, "is probably temperature, though



doubtless other conditions, such as presence of gulf weed, also have their influence."

The littoral species or "those found in moderately shallow water not far from the coasts, whether they be active swimmers, like *Loligo*, or more sedentary, like *Octopus*, are much more restricted in their range than the oceanic." Such have been referred to a number of regions, which agree very closely with those proposed by Dr. Paul Fischer, in his recent "*Manuel de Conchyliologie*," based upon a study of all the mollusks. Seventeen regions of this character are admitted, and the species, so far as known, are distributed in the following manner: Confined to one littoral area, 199 species; common to two littoral areas, 27; to three littoral areas, 12; to four littoral areas, 4; to five littoral areas, 1; to six littoral areas, 2; to ten littoral areas, 1. From these indications it appears that 80 per cent. of the species, so far as known, are confined to one area, "a striking confirmation of the proposition that littoral forms in general belong to many species, each of which is confined within narrow limits." The oceanic types are also limited in their distribution, as will appear from the exhibit tabulated by Mr. Hoyle. From one oceanic area, 66 species are known; from two oceanic areas, 15; from three oceanic areas, 3. In fine, "about 75 per cent. of the oceanic forms are confined to one ocean, and cosmopolitan forms must be regarded as exceptional."

Finally, "thirty-five species are recorded from both oceanic and littoral regions, but the majority of these are typically pelagic, and hence their occurrence in the latter areas must be regarded as accidental. Furthermore, it will be seen, that almost without exception, the littoral regions where a species has been found are those bordering upon its proper ocean, which is precisely what would have been expected."

#### PROTOCHORDATES.

##### *Tunicates.*

*The relations of the tunicates.*—The mooted question as to the relationships of the tunicates, and especially the degree to which they are connected with the vertebrates, has been again discussed. This has been done by Messrs. E. Van Beneden and C. Julia in a memoir on the morphology of the animals of that class. For knowledge of the details we must refer to the original memoir and to the full abstract in the *Journal of the Royal Microscopical Society*. In this place the suggestions as to the systematic position of the group can alone be considered:

(1) The Urochordata or tunicates form, in connection with the Cephalochordata (*i. e.*, Branchiostoma) and Vertebrata, a single primary group—the Chordata.

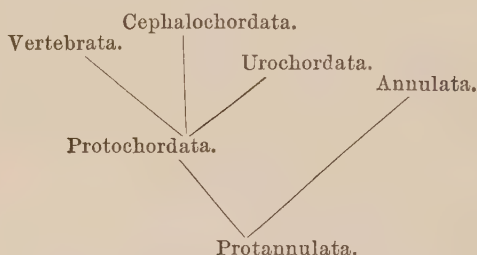
(2) "The tunicates have, like the other two divisions, arisen from segmented enterocœlous organisms, like the archiannelid worms. Animals



like Protodrili, but with dorsal chord, and anterior respiratory diverticula from the gut, formed the common starting point for the Chordata. In these Protochordata the posterior portion of the trunk is adapted more especially for locomotion, while the caudal region of the ancestral digestive tube has undergone progressive atrophy and the vegetative functions have become more localized in the anterior part of the trunk. The transformation of one part of the segmented body of the vermiform ancestors has affected all the trunk, except the cephalic extremity and first segment of the body, in those forms whence the Urochordata have arisen."

(3) "The affinities between Uro- and Cephalochordata are much closer than between either and the Vertebrata."

The manner in which the various groups have originated and the supposed degree of their relationship are exhibited in a scheme herewith presented:



(Arch. de Biol., VI, pp. 237-476, 9 pl.; J. R. M. S. (2), 1887, pp. 62-65.)

*Classification of the tunicates.*—The tunicates have been variously subdivided into orders, but according to M. F. Lahille all of these arrangements are more or less unnatural, and in his opinion the best basis for a primary classification of the class is furnished by the development of the gills. "The Salpidæ have a single row of holes on either side of their gill organs;" the Doliolidæ are similarly characterized, but the holes are more developed as well as more numerous. The Didemnidæ have three rows, and, finally, the Leptoclinidæ have four. In the "higher types the gill is larger, and is placed beside the intestine. In the Thaliacea the respiratory organ is very simple and without papillæ." Those forms, which are characterized by a simple gill, are grouped together under the name "Aplousobranchiata." Those in which "the gill is provided with longitudinal vessels" are grouped together under the name "Phlebobranchiata." Finally, those which "have longitudinal folds on the gills" are distinguished as "Stolidobranchiata." The progressive complication of the gill, it is affirmed, corresponds "to increase in the differentiation of the whole ascidian organism," and the proposed classification, it is urged, is therefore not the outcome of dependence on a single character, but the result of a co-ordination of

various systems. (*Comptes Rendus Acad. Sc. Paris*, cii, pp. 1573-1575; *J. R. M. S.* (2), vi, pp. 777, 778.)

#### VERTEBRATES.

##### *Fishes and fish-like forms.*

*Factors in the geographical distribution of American fresh-water fishes.*—Professors Jordan and Gilbert have published a "List of fishes collected in Arkansas, Indian Territory, and Texas," and have concluded with some general considerations on the distribution of the species:

(1) Many species have been regarded as very local, but research has shown that some of them have "a very wide distribution in the West and South, and what is true of these species will very likely be found true of all these now known from only a few localities;" such is especially the case with the small percoid fishes named *Etheostominae* or *Ethiostomatinae*.

(2) "As our knowledge of the geographical range of a species widens, it becomes necessary to extend our ideas of the range of variation included by it, and we are compelled to admit under it geographical varieties or subspecies." Eventually, therefore, a trinomial nomenclature must be adopted in ichthyology, as has been done in ornithology.

(3) "The environment and conditions of life being similar, the water communication being free, we have a similar fauna in regions widely separated." For example, the fishes of the Ozark region are substantially identical with those of the hilly regions of Tennessee.

(4) "Free water communication is essential to a varied fauna," and "the larger a river system the greater" is the "number of species in each of its affluents," while, on the contrary, short streams emptying into the ocean have a comparatively meager fauna.

The factors "favorable to the production in any stream of a large number of fishes" are (1) "clear water;" (2) "a moderate current;" (3) "a bottom of gravel, preferably covered by a growth of weeds;" (4) "water not too cold and not stagnant;" (5) connection with a large hydrographic basin; and (6) "little fluctuation in the year in volume of the stream or in the character of the water."

The conditions enumerated, it is added, are "well realized in the Washita River and in certain affluents of the Ohio and the Tennessee, and in these, among American streams, the greatest number of species has been recorded." (*Proc. U. S. Nat. Mus.*, 1886, pp. 1-25.)

##### *Selachians.*

*Relations of the extinct Hybodonts.*—The Hybodonts were sharks numerous in the ancient seas, and which have generally been supposed to be closely related to the Cestracions or Heterodontids, although much doubt has existed in the minds of some ichthyologists as to their exact affinities. Some remains of the lower jaw and the hyoid arches

of a cretaceous species, *Hybodus dubrisiensis*, have been studied by Mr. A. Smith Woodward, of the British Museum, with reference to this question. Without going into details, it may be observed that Mr. Woodward thinks that "on the whole, the form of hyoid arch" developed in this type bore "a greater resemblance to that of the Notidanidæ than to that of any other living family; it agrees in the fact that the hyomandibular and ceratohyal are most contracted at their point of union, but the elements are somewhat stouter than those both of *Heptanchus* and *Hexanchus*." He concludes that "it must suffice at present to add that, though there are well preserved pterygo-quadrates" from both the different geological horizons in which remains of the skeleton have been found, "there appears to be none but the most uncertain evidence of an articular facette on the otic process in any; and if this observation can be confirmed it will become of considerable interest when taken in connection with the fact pointed out by Professor Huxley, that the postorbital articulation in the living *Heptanchus* is only acquired comparatively late in the development of the fœtus. It is also interesting to note that one of the Liassic specimens exhibits traces of a persistent notochord, with the arches alone calcified, whereas in the cretaceous form," as has been shown by Mr. Woodward, "there are well differentiated centra." The differences between the anterior and posterior teeth are likewise more marked in *Hybodus dubrisiensis* than in any of the earlier species of which satisfactory remains are known. "It would appear indeed that there is distinct evidence of specialization, as the Hybodonts are traced through the Mesozoic period, and it is almost certain that future research in regard to structures other than teeth will lead to the subdivision of the multitudinous forms hitherto grouped under one generic name." (Proc. Zool. Soc. London, 1886, pp. 218-224, pl. 20.)

The question still remains an open one as to the degree of relationship of the Hybodonts to the Heterodontids, for it is scarcely probable that there is any close relationship between the former and the Notidanids.

### *Fishes proper, or Teleostomes.*

*Fishes with males larger than females.*—It has been believed by some ichthyologists, and especially affirmed by Dr. Günther, that "with regard to size, it appears that in all teleosteous fishes the female is larger than the male." This statement is altogether too general, and various exceptions are known. It is indeed possible that in a large proportion of those fishes whose males are distinguished by brilliancy of coloration or other striking secondary sexual characters, while the females are comparatively plain, the males are larger than the females. Such is the case at least with certain species of the family Gobiesocids. These fishes are common in certain waters, although rather local and rare along the coasts of eastern America. Several species are however

found along the British coasts, and in some localities some one or other may be quite abundant. The external appearance of some is also very striking. In the words of Mr. W. Anderson Smith, "No brush can give any adequate conception of the brilliancy of *Lepadogaster bimaculatus* from eight to twelve fathoms on scallop ground; or the vividness of coloring of the male of *L. Decandolii* in the breeding season. The prevailing tone of this fish is a somewhat sober-tinted combination of olive-greens and grays. At the breeding time the female is *much smaller*, less conspicuous in every way, and commonly marked with a band across between the eyes, which somewhat resembles the spectacle mark on the Cornish sucker of Couch—*L. gouanii* of Day. More timid, more active, slighter built, and more sober-tinted, the female might well have been supposed to be a different species from its brilliant companion, whose bright carmine spots on the dorsal fin commonly give him a sufficiently distinctive appearance."

The species of *Lepadogaster* are known, in common with other representatives of the family, as well as those of the family Liparididæ, as suckers, on account of the development on the breast or the ventral fins as a suctorial apparatus by means of which they attach themselves to stones and other substances, remaining fixed, as for example, a boy's sucker does when likewise applied. This characteristic seems to be a co-ordinate of other organs in the structure of the species so distinguished. "It would appear," says Mr. W. A. Smith, "as if a slender body and weak vertebrate system had developed" a "habit of clinging to the sea-ware and sea bottom that stimulated the pectoral region to meet the necessities of the situation, and in the case of *Lepadogaster* to cushion itself, the pectoral fins curving around the swelling bosom of the fish. Between these cushions depressions were left, and these proving very advantageous to the fish by their sucker action, the advantage was pursued by nature and transmitted." Differences prevail and specialization of various kinds supervene. "Although the small cushion-like disks of *Cyclopterus* and *Liparis* are the truest suckers, yet the species of *Lepadogaster* are perhaps the most truly sucker fish. This especially applies to *L. Decandolii* (Day), which is really a sucker fish all the way forward from the sucker proper itself; two-thirds of its length, and practically three-fourths of its weight and horizontal surface, is a sucker. By sucking up its lower jaw, and allowing its cartilaginous frame-work to rest on any object, the front jaw adds its sucking action to the sucker proper. This is aided by the plentiful discharge of mucus, in which the species emulates the unctuous sucker, *L. linearis* [*Liparis vulgaris*]."

The movements of the sucker-fishes are uncertain, and it is difficult to account for their changes. "At one time they will be comparatively common under stones on a certain piece of foreshore at low spring tide; and again they may be searched for in vain even in the same season of the year." This difference was supposed by Mr. W. A. Smith to be due to the prevalence or absence of rough water.



The Scottish species of *Lepadogaster* spawn in June and July. The eggs of all are large compared with the fish, and this, Mr. W. A. Smith adds, "may be said as a rule of shore fishes whose ova are comparatively few in number and more carefully watched over and tended by the parents. The eggs indeed of *Lepadogaster* may be readily counted, and average about one hundred and fifty." They are generally deposited in regular layers within the empty shells of scallops, and are usually "accompanied by the parent, curled up inside the shell, watching over the progress of their progeny; and if the dredge should bring up a shell thus supplied with ova from eight to twelve fathoms off scallop ground, if the fish is not in the shell, it is almost sure to be in the other contents of the dredge, showing it had either come out in the capture, or been watching close by."

It is nearly a month before the eggs of the *Lepadogaster Decandolii* are hatched, and the young then has "no sign of a sucker or the concomitant habits;" they are indeed "extremely active." The "development of the muscles that act upon the pectoral region are merely embryonic at forty-six days old," and it is not until some time afterwards that the suctorial apparatus is completely developed. (Proc. R. Physical Soc. Edinburgh, 1885-'86, pp. 143-150.)

*Variations in oviposition of Callichthyoid fishes.*—It had long been known that the *Hoplosternum* (or *Callichthys*) *littoralis* makes a nest and takes assiduous care of its young. Additional information has been recently given by Capt. J. A. M. Vipan, in observations made on fishes from Trinidad and preserved in the aquarium at his house in England. Two individuals "commenced making a nest on June 6 but that" and another they made three days later they soon pulled to pieces. "On the night of the 11th they began a new one; it consisted of pieces of *Vallisneria*, of the leaves of *Nymphaea* that were growing in the tank, which they bit off close to the roots of the plants, and a great quantity of river-moss (*Fontinalis antipyretica*), each piece being two or three times the size of the fish, so that it must have had hard work to bring them to the surface. They worked these materials together by some mucous substance until the outside was hard, the whole being under a quarter of an inch thick; they next buoyed up the structure with a quantity of mucous foam until it was raised  $3\frac{1}{2}$  inches above the water. The whole nest was 9 inches long and 7 inches wide, and somewhat resembled a finger-glass turned upside down on the top of the water, with the interior filled with froth. The fish kept swimming close under it all the time on their backs, and filling it with foam when finished. On the 12th the female shed her spawn between her ventral fins, which were clasped right together, and, when full, swam to the nest, and, turning on her back, deposited the spawn in it; this occurred several times, the male each time putting the spawn in its proper place and covering it with froth. As soon as the female had

dropped all her spawn the male took entire possession of the nest and would not let his mate go anywhere near it, and treated her so badly "that Captain Vipian had to "place her in another tank to save her life. Unfortunately the spawn was not good, only a few eggs hatching, and the young fishes dying soon afterwards."

Captain Vipian adds some interesting information relative to a small species of a genus allied to the *Hoplosternum*, the *Corydoras* (or *Callichthys*) *punctatus*. He bred large numbers of that little fish obtained from the Amazon, but "they never made the slightest attempt at making a nest, always depositing their spawn all over the tank, and even on the floating thermometer kept in it." He does not mention whether the male guarded the eggs, and it might be inferred indeed that such was not the case. Such neglect, however, would be exceptional among the Nematognathous fishes, inasmuch as the male almost always takes care of the eggs during maturation. (Proc. Zool. Soc. London, 1886, pp. 330, 331.)

*The constituents of white bait.*—The nature of the famous English luxury known as "white-bait" was for a long time doubtful. In the earlier part of the century it was generally referred to a peculiar species of the family of Clupeids, and the English naturalist Yarrell described it as a new species under the name *Clupea alba*, and by even such a distinguished ichthyologist as Valenciennes this view was not only accepted but the supposititious species was regarded as being a representative of a distinct genus, *Rogenia*, and consequently the *Rogenia alba* was inscribed for some time in the books as a specific name of the white-bait. Later the white-bait was very generally considered to be simply the young of the common herring. Still later observations, however, indicated that the problem was not to be so easily solved, and that the name white-bait, instead of indicating any specific fish, was rather a generic term under which various small fishes were combined, and recent investigation has been made by Prof. J. C. Ewart, who examined specimens obtained in the London markets for several months, from the middle of February to the middle of August, 1885. The results of this investigation are interesting and noteworthy. During February, out of fourteen hundred specimens examined, 93 per cent. were sprats and only 7 per cent herring; during March, of twelve hundred specimens examined, 95 per cent. were sprats and 5 per cent. herring; in April, of eight hundred specimens 86 per cent. were sprats and 14 per cent. herring; in May, of six hundred specimens 70 per cent. were sprats and 30 per cent. herring; in June, of eight hundred specimens 87 per cent. were herring and 13 per cent. sprats; in July, of six hundred specimens 75 per cent. were herring and 25 per cent. sprats; and in August, of five hundred specimens 52 per cent. were herring and 48 per cent. sprats. The specimens varied in length from about 1 inch to 3, but averaged in the neighborhood of 2.

The results thus obtained conclusively demonstrate that the nature of white-bait varies considerably; sometimes it consists almost entirely of sprats, while at other times it consists chiefly of herring; and not only does it vary as to the number of sprats and herring, but also in the size of these fish. "In February and March the white bait in the London market was almost entirely made up of about half-grown sprats; in April the white bait was smaller and the number of herring had considerably increased; in May, June, and July the white bait was almost entirely composed of small fish, many of them with only a few scales, and undoubtedly young herring." In August the herring were larger and fewer in number, while the sprats were considerably smaller. From the figures given, it will be evident that the white bait examined during the six months consisted of about 60 per cent. of sprats and about 40 per cent. herring, the sprats diminishing from 93 per cent. in February to 13 per cent. in June, and rising again to 48 per cent. in August; the herring rising from 7 per cent. in February to 87 per cent. in June, and falling to 52 per cent. in August." It is also noteworthy that in all the lots examined by Professor Ewart, there were a few small fish that belonged to neither the herring nor sprat species; there were, *e. g.*, gobies, small pipe-fish, sand-eels, and conger-eels, and, in addition to both, there were often shrimps and specimens of *Beroe*, and on one occasion a small octopus."

In view of these facts, it is evident that white bait can be enjoyed wherever the young of the clupeids can be obtained in sufficient abundance, and that even small fish or the young of other fishes can be administered as white bait. If it is desirable, then, white-bait dinners can be as readily provided for in the United States as in England. The white-bait dinner is indeed simply a matter of fashion, but the strength of this is shown by the fact that in Scotland, for example, when they were "spreading tons of absolutely fresh white-bait taken from the Forth" on the fields and "sending still larger quantities from the Tay to be manufactured into manure at Montrose," they were at the same time importing white bait at a considerable cost from London. (Proc. R. Physical Soc. Edinburgh, 1885-'86, pp. 78-81.)

*A new Pediculate fish of the family Ceratiidae.*—A group of remarkable deep-sea fishes of the order Pediculati, to which a number of forms have been added within the past few years, has received another notable addition during the past year. A single specimen, about 2 inches (49<sup>mm</sup>) long, was obtained by Capt. P. Andresen, a Norwegian sailing-master, in May, 1877, "floating in the sea," near the island of Madeira, and was presented to the museum of the Christiania University. It has, however, only been lately described by Prof. Robert Collett. Like so many of the other deep-sea forms, the new fish, has a very deeply cleft mouth armed with enormously long teeth at the front; its head is very large, and the deeply cleft mouth but moderately oblique; the body is com-



pressed and the "skin smooth; the spinous dorsal fin, is reduced to a single cephalic tentacle, the basal part of which is erect, not procumbent;" the soft dorsal and anal are very far back near the caudal and even more reduced than usual, the dorsal having only three unbranched rays and the anal two. But what especially distinguishes the new fish from its relations is the development of a long tentacle from the throat; the tentacle originates between the rami of the lower jaw "at a distance from the symphysis about equal to half the length of the jaw," and is "nearly three times and a half as long as the tentacle on the snout," extending a distance equal to that "from the front of the eye to the root of the caudal fin; it is thinner than the cephalic spine, and divides itself at the end into two short, pointed blades, the length of each being 6<sup>mm</sup>. Whilst the tentacle otherwise is black, the inner edges of these blades are white, like the upper half of the snout tentacle, and are furnished with a row of round papillæ, about thirty on each, resembling a chain of pearls. These small bodies undoubtedly have a use, either as organs of sense or as the source of a phosphorescent light." As usual in the family, the color of the new fish is "jet-black, with the exception of the upper half of the bulb of the tentacle on the snout and the inner margins of the ends of the guttural tentacle, which are white, but which in the living fish have probably been silvery and phosphorescent."

The fish thus distinguished has been named by Prof. Collett *Linophryne lucifer*, and would be regarded by some ichthyologists as the representative of a new subfamily within the family Ceratiidæ, to be named *Lino-phryninæ*.

Captain Andresen was on a voyage to the West Indies when he saw the fish. "He was capturing turtle in his boat; there was a heavy swell, but the water was smooth. After a time he caught sight of this little black fish, which lay on the surface quite alive, but almost motionless, which was not surprising when it was discovered that it had just swallowed a fish larger than itself. It did not lie on its side, but was apparently unable to swim. By getting the bailer under it he lifted it out with ease, and in order to keep it fresh he gave up his search for turtle and rowed back to the ship, where it was placed in spirit for preservation." The fish contained in the stomach was "one-half longer" than its captor, and belonged to the family Scopelidæ. (Proc. Zool. Soc. London, 1886, pp. 138-143, pl. 15!)

### *Amphibians.*

*Recent additions to the amphibians.*—In 1882 Dr. G. A. Boulenger published his catalogues of all the existing amphibians. Recently he has given the "first report on additions to the batrachian collection in the Natural History Museum," and it appears therefrom that sixty-three species of caudate amphibians (frogs, toads, etc.), four species of caudate (salamanders), and seven species of apodal amphibians (coecilians)



have been added since that time. The largest proportion of them have been described since 1882. Forty-five of the new species are represented by the types in the British Museum. (Proc. Zool. Soc. London, 1886, pp. 411-416, pl. 39.)

*Varieties of oviposition among the tailless amphibians.*—Great variety of oviposition is manifested by the tailless amphibians, and a very useful résumé of the information that has been collected up to the present time has been published by Dr. G. A. Boulenger, in connection with some observations by Dr. H. von Ihering "on the oviposition in *Phyllomedusa*." Most of the anurans lay their eggs in the water, but the exceptions are numerous and some of them very singular. Dr. Boulenger groups the eggs primarily into those in which the ovum is very small, in contradistinction from others in which the yolk-sack is very large.

In some "the ovum is small, and the larva leaves it in a comparatively early embryonic condition." Such are the ova of the great majority of the anurans. (1) Further, in most cases, they are laid directly in the water; all of the European types except of the genus *Alytes* display this mode of oviposition. (2) But by a few species "the ova are deposited out of the water." (a) Certain South American species deposit them "in holes on the banks of pools, which become filled with water after heavy rain," whereby the larvæ are liberated. The species so distinguished, as far as known, are *Leptodactylus ocellatus*, *Leptodactylus mystacinus*, and *Paludicola gracilis*. (b) A couple of other species likewise deposit their eggs out of the water, but instead of in holes, on the leaves of trees hanging over the water, so that the larvæ may drop down into the water after leaving the egg. One of the species thus distinguished is the *Chiromantis rufescens*, of West Africa, and another the *Phyllomedusa Iheringii*, of southern Brazil.

In other anurans "the yolk-sack is very large and the young undergoes the whole or part of the metamorphosis within the egg; at any rate, the larva does not assume an independent existence until after the loss of the external gills."

In some of these "the ova are deposited in damp situations, or on leaves, and the embryo leaves the egg in the perfect air-breathing form." Such are a true frog, *Rana opisthodon*, of South America, and a tree-frog, *Hylodes martinicensis*, of the island of Martinique.

In other cases "the ova are carried by the parent."

The parent in some instances is the male. (a) By the male of one species the eggs are carried in a chain "around the legs," while "the young leaves the egg in the tadpole state." Such a phase is manifested by the *Alytes obstetricans* of Europe. (b) In another instance the male takes care of the egg, but in another and very remarkable manner, for the eggs are carried about in a gular sack, which is simply a modification of the vocal, and "the young is expelled in the perfect state," such as the *Rhinoderma*.

In other cases it is the female that assumes the rôle of custodian to the eggs.

In one case the female carries the eggs "attached to the belly;" the *Rhucophorus reticulatus* of India is the only known species in which this method is manifested.

In another and long known species, the *Pipa surinamensis*, the eggs are "attached to the back of the female by the male, and her skin develops into cells for their reception, wherein the young complete their metamorphosis within the egg."

Equally remarkable instances of the carriage of the eggs on the back of the mother are furnished by the toads of the family Hylidæ and genus *Nototrema*. In all of these a special dorsal pouch is developed, and it is in allusion to this that the name *Nototrema* has been given. The species vary, however, in the extent to which they carry the young. In one form, the *Nototrema marsupiatum*, "the young leaves the pouch in the tadpole state," while in two other species, *Nototrema testudineum* and *Nototrema oviferum*, the young remain in the pouch until they have attained their natural form and are only then expelled. (Ann. and Mag. Nat. Hist. (5), xvii, pp. 461-464.)

### Reptiles.

*A remarkable Tortoise.*—The fauna of Papua, or New Guinea, has furnished within the last decade some very remarkable previously unknown types to naturalists, and not the least interesting of them is a new generic type of tortoises made known during the past year by Prof. E. P. Ramsay, of Sydney, New South Wales. The new type is referred to the family Trionychidæ, and, indeed, in a preliminary communication, the species was noticed as a member of the genus *Cyclanosteus*. The perusal of the description and an examination of the plate, however, show that its affinities to any of the known tortoises are very slight, and that it is not only not referable to any previously described genus, but should be kept apart from the family Trionychidæ at least. The carapace, or upper shell, is "shield-shaped, rounded, and high in front, pointed and keeled behind, and the plastron, or lower shell, is composed of "nine shields rounded anteriorly and posteriorly, the second and third pairs anchylosed to the marginals." In detail, "the plastron or ventral shield is flat, of nine plates," and the second, third, and fourth pairs of plates have a straight median suture, while the second and third pairs are anchylosed to the fourth and seventh marginals; "the whole of the plates of the carapace and sternum are covered with small round, raised rugations, or wavy irregular raised lines between shallow sculptures, towards the lower borders on the sides. These take an elongated form, sometimes parallel to the sutures." There are *no scutes*.

The head of the animal is "large, subquadrangular, narrowed anteriorly," and covered by six (?) plates, which are "anchylosed" and

"rugose;" the nostrils are "anterior," and the "jaws naked, with sharp cutting edges, the lower curved," and not notched.

What is especially remarkable, however, is the character and form of the members. The arms are "elongate, narrow, compressed, ridged on their rounded anterior portion, with narrow plates," and the nails are "free on first two digits only," the rest being "without nails and strongly webbed, the tips flattened," and "the third the longest." The hind legs are "short," and the first two toes have "strong, sharp nails," which nails are alone free, the rest of the toes being "strongly webbed to the tips."

The tortoise thus distinguished was obtained in the Fly River, and was a female of large size, the total horizontal length of the carapace being 18 inches, and along the curve of the back 19 inches, while the head and neck were about 7 inches long.

From the paragraphs of the description thus selected, it is not evident why the new tortoise should have been referred to the family of Trionychidæ. Apparently the only reason was because the scutes were not developed, and consequently a rudimentary or tense skin alone invested the bones. The differences manifested from all the Trionychidæ, however, are very great, and in the classification lately proposed or adopted by Professors Cope and Dollo it would belong to a different section of the order. In fact, assuming that the tortoise is a cryptodire, according to the classifications adopted by those gentlemen it would enter into the group of Clidosterna or Clidoplastra, inasmuch as the plastron unites "with the costal bones of the carapace by suture, with ascending axillary and inguinal buttresses."

But the assumption that the tortoise is a cryptodire is itself somewhat violent, and in view of the geographical distribution of the order to which it belongs it may quite likely prove to be a cryptodire.

But whatever may be the relations of the new genus, whether to the cryptodirous or pleurodirous tortoises, it has many quite peculiar characters. From all known forms it is apparently distinguished by the absence of scuta, the peculiar feet, and other characters. Undoubtedly, therefore, the new genus does not belong to any of the established modern families, and apparently not to any of the extinct ones named, although when more is known of *Carettochelys*, as well as the extinct forms, it may turn out that the Papuan animal is related to one of the families now regarded as extinct. Meanwhile, it will be better to isolate the genus, and regard it as the type of a peculiar family. This family of *Carettochelyidæ* has a "clidosternal" shell destitute of scuta; the carapace has six vertebral plates separated from each other by intervening costals, eight costal plates, the last two of which are connected mesially by the entire borders (no vertebral plates intervening), and ten pairs of marginal plates, as well as a nuchal and a pygal. The plastron is composed of nine plates, completely ossified and leaving no fontanelle, an "interclavicle" or mesosternal being well developed. The



head is wide and blunt in front, and the jaws are uncovered by lips. The feet are pinniform, with the first and second digits short and entirely involved in the skin, leaving only the claws exposed, while the third (which is the longest) and the succeeding have the last two phalanges elongated and exerted, but connected by an extensive web, and destitute of claws. (Proc. Linn. Soc. N. S. Wales (2), I, pp. 158-162, pl. 3-6.)\*

*A family of Lizards new for the American fauna.*—In Asia there are a few lizards having the eye entirely concealed by the skin, and with the tongue scaly, constituting the family of Anelytropidæ. Their life is mainly subterranean, and consequently they rarely come within the field of observation, unless specially sought for. In the examination of a collection of reptiles made by the geographical and exploring commission of the Republic of Mexico, Professor Cope detected a specimen evidently belonging to this family, which he has described as a new generic type, under the name *Anelytropsis papillosus*. The importance of this discovery, he thinks, "is considerable, as it shows that the scincoid lizards have undergone in the New World the same degenerative processes as in the Old World, and in the same way. This is a new fact, even supposing that the Aniellidæ of America are a degenerate form of the same family, which is not probable. Dr. Boulenger believes that that family is a degenerate type of the Anguid stem," and with this view Professor Cope is disposed to concur. *Anelytropsis*, according to Professor Cope, is "a degree further down in the scale than *Aniella*, in having the epidermis absolutely continuous over the eye, as in other members of the family of Anelytropidæ, and as in the Typhlopoid family of snakes." (Proc. U. S. Nat. Mus., 1886, p. 196.)

*The feat of an amphisbænoid lizard.*—A singular instance of the excavating powers and vitality of an amphisbænoid has been noticed by Dr. Boulenger, the keeper of the department of reptiles in the British Museum. A coral snake (*Elaps lemniscatus*) was found with an amphisbænoid, a species known as *Lepidosternon polystegum*, projecting from a hole in the anterior half of the body, while the posterior part protruded from the mouth of the snake. "The *Lepidosternon* had been swallowed headforemost by the snake, and had, apparently by means of its sharp-edged cutting snout, partly forced its way out of the body of its enemy, making its escape 3 inches from the mouth." (Proc. Zool. Soc. London, 1885, pp. 327-328; Am. Nat., xx, p. 178, Feb., 1886.)

*Earth-Snakes of India.*—A group of curious snakes is found in India and are peculiar to the main-land and the island of Ceylon, where they

\* *Postscript.*—After this report had been prepared, the "Annals and Magazine of Natural History" for March, 1887, was received, and in it is an article by Dr. Boulenger "On a new family of Pleurodirian turtles" (xix, pp. 170-172), in which *Carettochelys* is declared to be a Pleurodirian, and the representative of a peculiar family (*Carettochelydidae*). The more correct form is *Charettochelydæ*, (χελύς, χελυός.) Dr. Boulenger only knew the form through the description and figure above referred to.



are chiefly known as earth snakes; the scientific name is Uropeltidæ. They are almost worm-like in appearance and have a cylindrical body and a small head not distinct from the neck, small eyes, and the cleft of the mouth is of moderate width or much more restricted than in ordinary snakes. The tail is very short and truncated and terminates in "a rough shield, which is rounded, square, and more or less bicuspid, or flat with the caudal scales more or less keeled, or somewhat tapering, with a small terminal scute, which is 1—2 pointed, or with a horizontal ridge." It is in allusion to this terminal shield that the name Uropeltidæ owes its origin. The species of the family have their headquarters in "the western ranges of mountains from the Canara to Cape Comorin, only one species having been found on the mountains of the east coast, and only three north of the Kudra Mukh in South Canara, on the west side; some few only are widely distributed, others are exceedingly local and appear to be very rare in their localities." The species are further "peculiar to the mountainous districts or to the heavy forests at the immediate foot of the mountains." In such places, "they burrow into the ground, and are often dug up about coffee and tea estates; but they can always be collected by turning over logs and large stones in the forest, and even on the grass land at high elevation, and during the rainy season they are not unfrequently found along the roads. They are generally of small size (about 1 foot long) with a girth of scarcely an inch." The greatest length as yet known was reached by a *Silybura*, and was 24 inches. The maximum girth (3 inches) was realized in another species of the genus *Uropeltis*. "They never attempt to bite, however much they may be handled or teased; they will at once twine themselves tightly round a stick, and can be carried along without their attempting to escape. They are all ovoviviparous; they live almost entirely upon earth worms." The various species have been collected and comparatively studied by Col. R. H. Beddome, and he recognizes seven generic types and thirty-nine species; of these most have the tail truncated, but in several it tapers backwards. The genera are chiefly marked by peculiarities of the caudal or terminal shields. Nineteen of the species belong to one genus (*Silybura*), while only one is recognized of the typical genus (*Uropeltis*). (*Ann. and Mag. Nat. Hist.* (5), xvii, pp. 3-33.)

### *Birds.*

*The cubital coverts of birds.*—Along the preaxillary portions of the wings of birds, or close by the bones of the arm, are developed small feathers more or less imbricated, known as cubital coverts. "A reference to the wing of the Golden Plover, a central type, and one that in itself represents all the leading modifications," says Mr. Goodchild, "may help to make the nomenclature" used by him the "more intelligible." The "terms used referred mainly to the relations of various parts of the wings to each other and to the body axis, when the wing is

extended and is viewed from the dorsal or upper surface. The wing-surface is primarily divided into the manual (primary) region and the cubital (secondary) region, this last embracing all the feathers that originate from any part of the forearm or cubitus." Of the manual region, Mr. Goodchild has nothing to say. "In the cubital region the remiges, and the greater coverts that come on next above them, are uniform in disposition in all carinate birds. In these feathers the overlap is uniformly distal; that is to say, the several feathers are disposed in such a manner that the outer free edges of those nearer the vertebral axis overlap the inner edges of those originating near the distal extremity of the wing. The same observation applies also (but with some minor modifications of detail) to the lesser coverts, or those feathers that mainly originate in the patagium, and that extend along the anterior border of the wing from the humeral fold to the carpal joint. The remaining feathers, which are generally comprehended under the term median coverts, vary considerably in both their direction of imbrication and in the number of rows that run parallel to the greater coverts in each case." The object of Mr. Goodchild was to consider "the nature and the extent of the variation referred to, without regard to the morphological details of any other kind soever." Many of the facts signalized by him "have either not been noticed, or else, if they have been noticed, their significance appears to have been missed." For convenience of description, the tract occupied by the median coverts has been divided by Mr. Goodchild into "three areas by lines parallel to the main direction of the cubital quills." (1) The area nearest the vertebral axis is referred to as "the proximal area;" (2) that next is called the "middle area," and (3) the remaining "up to the distal border next the manual region" is distinguished as the "distal area." The "rows of feathers composing the median coverts range, in a general way, parallel with the greater coverts; the number of rows varies from one to six, or even more, in different forms of birds; and the row nearest the greater coverts is the one most subject to variation in the disposition of the feathers composing it."

Many of the results reached by Mr. Goodchild in his investigations are interesting. While some bring additional confirmation to the views accepted by systematists of the relations of various birds, others contravene such views and may possibly indicate affinities other than have been accepted.

The passerine style of imbrication represents one system of arrangement well exemplified by the wing of the thrush or migratory robin. In the crows, "an approach toward a somewhat different mode of arrangement is made," and "another minor modification is seen in the *Alaudidæ*" or larks. "The swallows all appear to follow the normal passerine type," but that of the swifts appears to be essentially different.

With reference to the mooted question of the propriety of the group-

ing of the humming-birds with the swifts, Mr. Goodechild has something to say.

Mr. Goodechild examined the whole of the Gould collection of humming-birds, and "checking the results by comparing them with those made on a large series of other specimens," he was "convinced that one general type of wing-pattern characterizes the whole of these birds; it is of a very simple character," and distinguished by the fact that "the proximal lapping row of median coverts found throughout all the passerines is absent entirely" in the humming-birds. These "might, indeed, be described as possessing no median coverts at all, the place of these being taken up by feathers having the same mode of imbrication as the lesser coverts. All the feathers of each series overlap outwards and backwards from the vertebral axis towards the distal end of the wing in these birds."

Comparison of the swifts with the humming-birds was significant. "Observations on the order of overlap in the wing of freshly killed specimens of *Cypselus apus*, afterwards extended by an examination of the whole series of swifts in the national collection, showed that in these, as in the humming-birds, no one series of feathers overlaps backward. In fact the wing-pattern in the genera *Cypselus*, *Acanthylis*, *Chaetura*, and *Collocalia*" seemed to him to "differ in no essential respect from that found throughout the trochilidæ. So far as the disposition of the wing coverts is concerned, the swifts and humming-birds agree among themselves, and differ from all of the Passeriform birds, with the possible exception of the birds of paradise."

The gallinaceous birds, according to Mr. Goodechild, rank "near to the accipitrine," and "perhaps leading away from them somewhere near the Polyborine birds." In the case of the turkey (*Meleagris*) "proximal overlap characterizes nearly all the median cubital coverts, as in the Accipitrines," and in this respect "the turkey stands alone amongst the Gallinæ;" but neither in the turkey "nor in any one of the Alecteropods do any traces of the upper wing-coverts exist."

Among the pigeons it is interesting to note that the large goura is distinguished from the ordinary pigeons by some well-marked characters. The cubital covering exemplified in the goura approaches that of the curassows and is very different from that of the typical pigeons. The difference appears to Mr. Goodechild to be "both striking and significant," and he has correlated the differences observed in the cubital coverts with other characters.

(1) "In the normal pigeons an oil-gland is present; but is absent in *Goura*."

(2) "In the normal pigeons the tail-feathers are 12 in number; while there are 16 in *Goura*."

(3) "In the normal pigeons the pterylosis is columbine; and is galline in *Goura*."

(4) "In the normal pigeons cæca are present; but are absent in *Goura*."



(5) "In the normal pigeons a gall-bladder is present; no gall-bladder in *Goura*."

(6) "In normal pigeons incubation lasts 16 days, but extends to 28 days in *Goura*."

In view of these characters there seems to be no doubt that *Goura* is the type of a family quite distinct from the Columbidae and the rest of the columbine birds. It is noteworthy that, excepting *Goura*, the pterographic characters of the Columbæ are remarkably uniform throughout.

The family Pteroclidæ has been generally approximated to the columbine series. *Pterocles arenarius* "shows an arrangement of the wing-feathers somewhat like that of the pigeons, especially so far as the proximal and the distal areas of the cubital region are concerned. But the distal imbrication of all the feathers next the manual region is, in the Pterocletes, carried to excess. In this respect the Pterocletes stand as far removed from the pigeons as these are from the Gallinæ."

With regard to the shore or wading birds, it is remarked that "if we start with the Plovers as the representatives of the order," the pterographical characters "nearly approach those of the pigeons." And "from the central forms of the Limicolæ, nearly all the modifications of style observable in the Carinatae could be traced without difficulty." Thus, "in one direction, and at no remote distance from the Plovers, we come to the Rails;" in another "gradations equally gentle conduct us to the Gulls and the Terns." Again, "along another line of modification we arrive at the Cranes. The Storks again stand at no great distance." Further, "each of the forms here mentioned, in turn, leads to others more distantly removed from the central type."

Sometimes curious resemblances appear; thus, "between the style of the median cubital coverts in *Leptoptilus*," one of the Storks, and that of the turkey buzzards, or cathartids, Mr. Goodchild "failed to detect any difference of importance in respect of the feature specially under notice. "So far as the imbrication of the wing-coverts is concerned, *Leptoptilus* and the Cathartidæ might even stand in the same family."

On the other hand, some forms which agree closely with others in structure differ considerably in the cubital covering. One of these is the common Osprey or *Pandion* and another is the Kite or *Milvus*.

The conclusions of Mr. Goodchild are very temperate and judicious. "In regard to any conclusions connected with taxonomy that may be drawn from a study of the facts herein referred to, there will probably be much difference of opinion." But "there can be little doubt, also, that up to a certain point there is a remarkable correlation of particular styles of imbrication of the cubital coverts with certain structural characteristics—osteological, myological, visceral, and pterographical; so that, within certain limits, the disposition of the cubital coverts may be taken as a kind of index to the presence, or the absence, of deeper seated characters whose importance in relation to taxonomy is generally recognized." (Proc. Zool. Soc. London, 1886, pp. 184–203.)



*A new check-list of North American birds.*—When the “American Ornithologists’ Union” was organized, in September, 1883, a resolution was passed “that the chairman appoint a committee of five, including himself, to which shall be referred the question of a revision of the classification and nomenclature of the birds of North America.” The gentlemen appointed on this committee were Dr. Elliot Coues, Mr. J. A. Allen, Mr. Robert Ridgway, Mr. William Brewster, and Mr. H. W. Henshaw. These were also materially assisted by Mr. Leonhard Stejneger. The result of the deliberations of the committee was published in 1886 under the title of “The Code of Nomenclature and Check-list of North American Birds, adopted by the American Ornithologists’ Union.” The work thus published differs considerably from its predecessors. The “principles, canons, and recommendations” for nomenclature were considered at length and have been published as a portion of the volume. Those most essential are three. “Canon 13” premises that “zoölogical nomenclature begins at 1758, the date of the tenth edition of the ‘*Systema naturæ*’ of Linnaeus;” “Canon 42” provides that “the basis of a generic or subgeneric name is either (1) a designated, recognizably described species, or (2) a designated, recognizable plate or figure, or (3) published diagnosis;” “Canon 43” further proclaims that “the basis of a specific or subspecific name is either (1) an identifiable published description, or (2) a recognizable published figure or plate, or (3) the original type, specimen, or specimens absolutely identified as the type or types of the species or subspecies in question.”

It was likewise provided that a system of trinomial nomenclature should be adopted, where such was required, under the regulation of canon 11. That canon states “Trinomial nomenclature consists in applying to every individual organism, and to the aggregate of such organisms known now to undergrade in physical characteristics, three names, one of which expresses the subspecific distinctness of the organisms from all other organisms, and the other two of which express respectively its specific indistinctness from or generic identity with certain other organisms; the first of these names being the subspecific, the second the specific, and the third the generic designation; the three, written consecutively, without the intervention of any other word, term, or sign, constituting the technical name of any subspecifically distinct organism.”

The names adopted in consonance with these several canons are arranged in a different sequence from any previous list, and in fact the lists previously published by the Smithsonian Institution and Dr. Coues are practically inverted, the intention being to commence with the generalized types, and proceed to the more specialized and highly developed ones. It has for this purpose been assumed that the previously recognized relations were approximately correct, and that only an inversion was needed to present the system in its new phase. It will probably be found hereafter, however, that the exigencies of classifica-

tion have not been yet successfully disposed of. The species embraced within the North American fauna are referred to sixty-six families and seventeen orders. These orders, it must be always remembered, have much less taxonomical value than the orders of other classes of the animal kingdom, and are in fact probably more nearly of the value of what have been called super-families. It may also be added that the families of passerine birds have been accepted with approximately the limits generally conceded to them, and consequently the species of the passerine group occurring within the limits treated of are referred to as many as twenty families, but of these few have tangible characters. The series of families commences with the three of the order Pygopodes and terminates with the Passerine. As many as seven hundred and sixty-eight species of birds are recognized as belonging to the North America fauna, and besides these there are numerous subspecies. A so-called "hypothetical list" is added, including the names of twenty-six species which have been at various times ascribed to the North American fauna, but which, for various reasons, are now excluded, although some of them may hereafter be legitimately added.

## I. Pygopodes.

## a. Podicipides.

## 1. Podicipidæ.

## b. Cephpi.

## 2. Urinatoridæ.

## 3. Alcidae.

## II. Longipennes.

## 4. Stercorariidæ.

## 5. Laridæ.

## 6. Rynchopidæ.

## III. Tubinares.

## 7. Diomedeidæ.

## 8. Procellariidæ.

## IV. Steganopodes.

## 9. Phaëthontidæ.

## 10. Sulidæ.

## 11. Anhingidæ.

## 12. Phalacrocoracidæ.

## 13. Pelecanidæ.

## 14. Fregatidæ.

## V. Anseres.

## 15. Anatidæ.

## VI. Odontoglossæ.

## 16. Phœnicopteridæ.

## VII. Herodiones.

## a. Ibides.

## 17. Plataleidæ.

## 18. Ibibidæ.

## b. Ciconiæ.

## 19. Ciconidæ.

## c. Herodii.

## 20. Ardeidæ.

## VIII. Paludicolæ.

## d. Grues.

## 21. Gruidæ.

## e. Ralli.

## 22. Aramidæ.

## 23. Rallidæ.

## IX. Limicolæ.

## 24. Phalaropodidæ.

## 25. Recurvirostridæ.

## 26. Scolopacidæ.

## 27. Charadriidæ.

## 28. Aphrizidæ.

## 29. Hæmatopodidæ.

## 30. Jacanidæ.

## X. Galinæ.

## f. Phasiani.

## 31. Tetraonidæ.

## 32. Phasianidæ.

## g. Penelopes.

## 33. Cracidæ.

## XI. Columbæ.

## 34. Columbidae.

## XII. Raptores.

## h. Sarcorhamphi.

## 35. Cathartidæ.

## i. Falcones.

## 36. Falconidæ.

## j. Striges.

## 37. Strigidæ.

## 38. Bubonidæ.

## XIII. Psittacidæ.

## 39. Psittacidæ.

## XIV. Coccoyges.

k. Cuculi.

40. Cuculidæ.

l. Trogones.

41. Trogonidæ.

m. Aleyones.

42. Alcedinidæ.

## XV. Pici.

43. Piciidæ.

## XVI. Macrochires.

n. Caprimulgi.

44. Caprimulgidæ.

o. Cypseli.

45. Micropodidæ.

p. Trochili.

46. Trochilidæ.

## XVII. Passeres.

q. Clamatores.

47. Tyrannidæ.

r. Oscines.

48. Alaudidæ.

## XVII. Passeres—Continued.

r. Oscines—Continued.

49. Corvidæ.

50. Sturnidæ.

51. Icteridæ.

52. Fringillidæ.

53. Tanagridæ.

54. Hirundinidæ.

55. Ampelidæ.

56. Laniidæ.

57. Vireonidæ.

58. Cœrebidæ.

59. Mniotiltidæ.

60. Motacillidæ.

61. Cinclidæ.

62. Troglodytidæ.

63. Certhiidæ.

64. Paridæ.

65. Sylviidæ.

66. Turdidæ.

*Recent abundance of a little-known Shearwater.*—Only a few years ago (in 1881) a previously unknown species of Shearwater was discovered off the coast of Massachusetts, and made known from a single specimen by Mr. Cory. It was named *Puffinus borealis* and it has become popularly known as Cory's Shearwater. Not a single other specimen had been obtained since, until the summer of 1886. Towards the end of September, however, herring approached the shore in great numbers, from Point Judith to Buzzard's Bay, and Vineyard Sound, and in their wake were enormous numbers of Shearwaters and Jaegers, and singularly enough the Shearwater proved to be almost exclusively the rare *Puffinus borealis*; among them, however, were a few of the *Puffinus Stricklandi*, but none of the *Puffinus major*. "The Shearwater occurred in flocks of perhaps from fifty to two or three hundred, the bunches being generally found quietly resting on the water, and feeding, while swimming, upon the herrings that were so abundant in the vicinity. They were very tame, but approach to them could be best made by a steam-launch, which would almost run over them before they would start to fly. A dozen birds were killed by the discharge of two guns from a launch. About a hundred specimens were secured, and thousands could easily have been killed if necessary." Subsequently, the Shearwater remained along with the herring and occurred "abundantly off Gay Head, Menemsha Bight, Cuttyhunk, and elsewhere, both in Vineyard Sound and Buzzard's Bay." The previously excessively rare Shearwater will consequently be hereafter in most of the principal ornithological cabinets, for large numbers were obtained for that purpose. (Auk IV, pp. 71-72.)

*Mammals.*

*The eggs of Tachyglossus.*—It was noticed last year that the spiny anteater or Tachyglossus of Australia has been found to be oviparous and

to carry a single egg in a marsupium or pouch. Professor Ramsay has given some additional information in regard to the egg, the pouch, and the characteristics of the mother at the time of ovulation. His observations were based upon four females. On examining the pouch of one he found therein "an egg, white in color, and about half an inch in length, having a rather tough skin," and with very little lime in it, and on the whole, much like a reptile's egg; it is oval and equally rounded at the respective ends. "The pouch was much warmer than the body of the echidna generally," and Prof. Ramsay was surprised to notice the degree of warmth when he put his fingers in it. "The pouch entirely disappears, or rather does not appear at all, until the parent is about to lay her egg." The mother "showed great resentment at being examined," and, "on placing her in a cask of sand she at once burrowed out of sight, covering herself with sand to a depth of 4 inches." In captivity all animals were "fed on fresh milk, sweetened with a little sugar, and some bread crumbs added." Some became tame very soon, and readily went after the milk; others did not drink except when their keeper was out of sight. (Ann. and Mag. Nat. Hist. (5), XVI, p. 479.)

*The embryo of the armadillos.*—Until comparatively lately but little was known concerning the embryology of the edentate mammals, but information has been gradually accumulating, and we are now acquainted with the outlines of the development of each living type of the order.

Some additional information respecting the fetal stages of the armadillos has been published by Dr. H. von Ihering. Dr. von Ihering's researches were chiefly based upon the *Praopus hybridus*, a southern Brazilian species. It appears that "several fœtuses—six or more—are inclosed in a single chorion, which is surrounded by as many zonary placentaë as there are fœtuses;" the zones thus constituted are not, however, perfect. It appears that the ungual phalanges in the embryo differ from those of the adult in that they are "wide and hoof-shaped with a trilobate margin," instead of being long and claw-shaped, as they are in later life. This fact is of special interest, inasmuch as it recalls characteristics exemplified in the gigantic extinct relations of the armadillos known as Gyptodonts. Another very interesting feature is the apparent development of a male organ in every individual of the litter, thus apparently corroborating a popular idea that the young are always males. Perhaps however in this case we have an analogy of a feature exemplified in the striped hyena, in which the clitoris is so excessively developed as to simulate the male organ. (Kosmos, —; and Am. Nat., XX, pp. 667-678.)

*Alternation of generations in armadillo.*—Dr. H. von Ihering has shown that in the armadillos known as *Praopus* eight embryos result from a single germ; and having considered this fact in connection with



others furnished by the animal kingdom, he has enunciated some rather curious propositions to which he was led.

According to Dr. von Ihering, "in all groups twins may occur from one ovum; the polar bodies are morphologically nothing less than abortive germs; in fact, the origin of the multiple embryos from a single ovum is the primitive condition; the development of only one is the secondary and adaptive. Now if this be pressed to its logical conclusion," continues Dr. von Ihering, "one would be forced to the paradoxical conclusion that the *Praopus*, for instance, brings forth grandchildren, and that the mother of twins from one ovum is really their grandmother." If this be so, the categories previously admitted in the schemes of development are evidently insufficient, and Dr. von Ihering has proposed a revised classification, as follows:

I. "Hologenous Development (Haeckels' hypogenesis). The fertilized ovum develops with or without metamorphosis into a *single individual*.

II. "Merogenous Development. The fertilized ovum develops into *two or more individuals*, which

A. "return directly to the parent form and mode of reproduction (*Temnogenesis*), or,

B. "exhibit an antithesis of diversely reproducing individuals or generations (*Metagenesis*, or *Alternation of Generations*)

(a) "*Calycogenesis* in *Salpæ* and *Medusæ*,

(b) "*Pædogenesis* in *Cecidomyæ*,

(c) "*Heterogenesis*, in which either both generations reproduce sexually or one or several multiply parthenogenetically." (Biol. Centralbl., VI, pp. 532-539; J. R. M. S. (2), VII, p. 44.)

*The species of Manatee.*—A few years ago a species of Manatee was described as peculiar to the headwaters of the Amazon. The specimens on which the species was based were obtained in the early part of the century by Dr. Natterer, but for many years it had remained undescribed. This species and the other representatives of the genus have been recently investigated by Dr. C. Hartlaub. The result of Dr. Hartlaub's examination of all the specimens accessible to him of the family of Manatees is a confirmation of the species indicated, *Manatus* (rather *Trichechus*) *inunguis* and the ascertaining of good characters. Two other of the formerly recognized species are admitted, and for them the names *senegalensis* and *latirostris* are retained. The former, as is of course indicated by the name, is of African origin, and the latter occurs in the West Indies and along the Florida coast. For the details of the differences between the various species, reference must be made to the memoir of Dr. Hartlaub in the "*Zoologische Jahrbücher*." Here it can only be stated that the differences are well marked in the young as well as in the adult. Some of the most salient are the differences in the width and extension of the facial bones, the character of

the ribs and zygomatic arches, and the size of the teeth. The molars of *T. senegalensis* are especially remarkable on account of the large size and the extension of the series forwards, while in the American species they are much smaller and the series terminate considerably in front of the antorbital foramina or under the zygomatic processes. There can be no question that the three species thus recognized at least are perfectly distinct. (1) Under the African species for which the name *Manatus senegalensis* is retained, the *Trichechus manatus* of Linnæus and the *Manatus nasutus* and *M. Vogelii* are embraced. (2) The common American species is called *Manatus latirostris*, and to the species for which this name is retained are referred the *Manatus americanus* and *M. australis* of most authors, but not the *T. australis* of Shaw. (3) The third species is the *Manatus inunguis*. Individuals of the species have been known but have been confounded by previous authors with the common American species. (Zool. Jahrbücher, 1886.)

#### NECROLOGY OF ZOOLOGISTS, 1886.

- BECHER (EDWARD), died November 11, 1886, at Vienna; an entomologist, and assistant in the Imperial Museum.
- BENECKE (BERTHOLD), died February 27, 1886, aged forty-three; an ichthyologist and pisciculturist.
- BOECK (EUGEN VON), died January 30, 1886, in Cochabamba, Bolivia; an ornithologist.
- BUSK (GEORGE), born 1807, died August 10, 1886; especially notable for his labors on the Polyzoans.
- COBBOLD (T. SPENCER), born 1828 in Wortham, Suffolk, died March —, 1886, at London; an eminent helminthologist.
- COLE (WILLIAM WILLOUGHBY), Earl of Enniskillen, born 1807, died November 21, 1886; well known for his collection of fossil fishes.
- CORNET (FRANÇOIS LEOPOLD), born at Givry, Belgium, February 21, 1834, died January —, 1886; best known for his work on the cretaceous formations.
- FISCHER (GUSTAV A.), died November 11, 1886, at Berlin; an ornithologist and African traveler.
- FISCHER (HEINRICH LEOPOLD), born ———, died February 1, 1886; well known for his contributions to the knowledge of orthopterous insects.
- GIRARD (MAURICE), died August —, 1886, aged sixty-four; an eminent French entomologist.
- GUISCARDI (GUGLIELMO), born at Naples, March, 1821, died at Naples, December 11, 1885; a palæontologist.
- HALLER (GUSTAV), died May 1, 1886, at Bern; well known for his studies on the mites.
- HAROLD (BARON EDGAR VON), died August 1, 1886, at Munich; a celebrated coleopterist.

HORNIG (JOHANN VON), died November 29, 1886, at Vienna; a lepidopterist.

JENKINS (HENRY MICHAEL), born near Llandaff, June 30, 1841, died 1886; a student of the mollusks.

KNOX (ARTHUR EDWARD), died September 23, 1886, near Arundel; an English ornithologist.

LEA (ISAAC), born at Wilmington, Delaware, March 4, 1792, died at Philadelphia, December 8, 1886; an eminent student of the mollusks and especially of the unionidæ.

LICHTENSTEIN (JULES), died at Montpelier, November 20, 1886, at the age of sixty-eight; a special investigator of the aphides.

LIÉNARD (VALÈRE), died August 20, 1886, at the age of thirty, in Brussels; a comparative anatomist.

MORREN (CHARLES JACQUES EDOUARD), died February 28, 1886, at Louvain; a casual investigator in zoology, but better known as a botanist.

PEACH (CHARLES WILLIAM), died February 28, 1886, aged eighty-six, at Edinburgh; a student and collector of English animals.

PLÖTZ (KARL), died August 12, 1886, in Greifswald, at the age of seventy-three; a well known lepidopterist.

POLLEN (FRANÇOIS P. L.), born in Rotterdam January 7, 1842, died January 7, 1886, at Leyden; well known on account of his collections and investigations in Madagascar.

POWER (JOHN ARTHUR), born March 18, 1810, died June 9, 1886, in Bedford; an English coleopterist.

SCHÖDLER (J. EDOUARD), died November 19, 1886, at Berlin; known on account of his studies of the crustaceans of the family Daphnidiidæ.

TSCHUDI (JOHANN JAKOB VON), born June 25, 1818, at Glaris, died January 24, 1886, at St. Gallen, Switzerland; a zoologist and traveller.

## ANTHROPOLOGY IN 1886.

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By OTIS T. MASON.

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### INTRODUCTION.

In this introduction to the progress of anthropological work in 1886, attention will be drawn to comprehensive summaries, courses of lectures, and description of instrumentalities. It is well known that original investigation, instruments of precision and research, and philosophical discussions are three distinct elements of progress in any science, which are mutually dependent, which severally move forward in a line marked out by the other two, and whose momentum is decided by dynamic and kinetic forces regulated by the other two. The final stage of progress is instruction, whereby the results of investigation are popularized and became part and parcel of universal thought and action.

Instruction in anthropology is better organized in Paris than in any other city. By this it is not designed to say that anthropological research of the highest order is confined to the French capital. What is emphasized is this, that in the *École d'Anthropologie* and other public lectures the French anthropologists have come to realize the crowning function of any science.

The course in the *École* in 1885-'86 included the following subjects and lectures:

(1) Zoological anthropology, by Dr. Mathias Duval. Programme: Anthropogeny and comparative embryology; the blastoderm and the first phases of development.

(2) General anthropology, by Dr. Paul Topinard. Programme: Type and race. Part I, races of Europe from prehistoric times to our day; Part II, succession and transformation of races in time, their past and their future.

(3) Ethnology, by Dr. Dally. Programme: Ethnic craniology; normal and abnormal skulls; prehistoric anthropology, by M. Gabriel de Mortillet; tertiary man; origin of man; medical geography, by Dr. Bordier. General action of environment.

(4) History of civilizations, by Dr. Letourneau. Evolution and ethnology of ethics. The course of linguistics had been given in the previous summer.



The minister of public instruction added to the course in the École des Hautes Etudes a fifth section on the science of religion. To show the scope of these lectures the programme is added:

Religions of India, by M. Bergaigne. Religion of Egypt, by M. Lefebure. Religions of the Far East, by M. de Rosny. Semitic Religions, by M. Maurice Verner. Islamism and the Religions of Arabia, MM. Hartwig and Derenbourg. The Hebrew Language, M. Carrière. Origin of Christianity, by M. Ernest Havet. History of Dogmas, by M. Albert Reville. Christian Literature, by MM. Sabatier and Massebrian. History of the Christian Church, by M. Jean Reville. History of Canonical Law, by M. Esrnein.

Chairs of anthropology have been established in Rome, in several German universities and in one or two American colleges, examinations being necessary to a degree.

*The Inconographic Encyclopædia.*—The second volume of this publication is based on von Eye's *Culturgeschichte*, but has a chapter on prehistoric archæology, by Prof. Daniel G. Brinton, which doubles the value of the original work. We have no hesitation in placing this article at the head of all compendiums upon this subject. The method of treatment is historical. The introductory chapter is devoted to a sketch of the science and the methods and problems which have for the past quarter of a century engaged the minds of archæologists. The characteristics and art production of the European age of stone in its two periods, the palæolithic and neolithic; the age of bronze and the age of iron are treated in the first fifty pages.

The prehistoric archæology of the western hemisphere is treated under the following analysis:

#### I. Palæolithic period.

1. The palæolithic period of North America.

3. The palæolithic period of South America.

Concluding remarks on the palæolithic period.

#### II. Neolithic period.

##### A. Archæology of the United States.

1. Art in stone.

2. Pottery.

3. Bone.

4. Shell.

5. Metals.

6. Other ancient remains.

##### B. Archæology of Mexico and Central America.

1. Art in stone.

2. Metals.

3. Pottery.

#### II. Neolithic period.

##### B. Archæology of Mexico and Central America.

4. Bone and shell.

5. Paper.

##### C. Archæology of Andean nations.

1. Art in stone.

2. Art in bone, shell, and wood.

3. Metals.

4. Pottery.

5. Other arts.

##### D. Archæology of southern and southeastern South America and the West Indies.

1. Art in stone.

2. Pottery.

3. Metals, bones, and shell.

General observations on American art.

In the second number of the *Revue d'Anthropologie* of the current year Dr. Topinard commences a series of catalogues of the prehistoric

crania in France, as well as a bibliography of anthropological papers appearing in current journals. This work can not be too highly commended. It would occupy only a little more space to give the number of pages in each, and this would secure the thanks of many collaborators. Each year brings us thus nearer to a coöperative bibliography of anthropology throughout the world.

*Anthropological literature.*—Catalogue in Archiv für Anthropologie, XVI, Supplement, pp. 1-135.

- I. Pre-history and Archæology, J. H. Müller, 1-30 pp
- II. Anatomy, Ad. Pansch., 31-36 pp.
- III. Volkerkunde, Dr. R. Scheppegg.
  - (1) *Sources*, such as general literature, bibliographies, annals, journals, congresses, museums, and expositions.
  - (2) *Ethnology*: methodic, general sociology, special sociology in characteristics, family, domestication, mutilations, medicine, justice and the state, religion, language, technology.
  - (3) *Ethnography*, studied geographically.
- IV. Zoology, as related to anthropology in recent and fossil mammals.

#### Congresses in 1886:

Association Française pour l'Avancement des Sciences, at Nancy, August 12-20.  
 British Association for the Advancement of Science, Birmingham, September 1-8.  
 American Association for the Advancement of Science, Buffalo. Aug. 27-Sept. 7.  
 German Congress of Anthropologists, in Stettin, August 10-17.  
 Norwegian Association for the Advancement of Science.  
 Seventh Congress of Orientalists, Vienna, September.



























































#### ARCHÆOLOGY.

One of the most thorough archæological investigations ever undertaken is that of Professor Putnam, of Cambridge, and Dr. C. L. Metz, in the mounds of the Little Miami Valley, especially in the Marriott and the Turner Group. The minute account of these diggings will occupy a separate memoir, but in the eighteenth and nineteenth annual report of Peabody Academy enough is told to give a clear outline of the work. The scientific value of this exploration is due to the method, to the application of detailed biological processes throughout. Not only is every ounce of earth passed backward through a screen or sieve, but the explorers have made some of their best finds beneath the original surface. Dr. Whitney has made a study of the human bones and reports the lesions to belong to three classes: (1) Anomalies or variations from type; (2) those that have followed from injuries; (3) those resulting from disease.

The archæological explorations of the Bureau of Ethnology were still under the direction of Mr. Cyrus Thomas, and not only embraced the United States, but extended southward through Mexico and Central America.

Recognizing the value of geographical distribution as a concept in dealing with archæological phenomena, Major Powell has devised a scheme of conventions for the archæologic cartography of North America. This is published in his fourth annual report of the Bureau of Ethnology and should be adopted at once by all who write upon American archæology.

SCHEME OF CONVENTIONS FOR THE ARCHÆOLOGIC CARTOGRAPHY OF NORTH AMERICA.

 Indian village.	 Burial mound.
 Wood lodge.	 Mound with single stone grave.
 Group or village of wood lodges.	 Mound with stone graves.
 Earth lodge.	 Grave or single burial.
 Group or village of earth lodges.	 Cemetery.
 Stone lodge.	 Stone grave.
 Group or village of stone lodges.	 Stone grave cemetery.
 Cliff lodge.	 Ossuary.
 Group or village of cliff lodges.	 Inclosure.
 Cavate lodge.	 Inclosure with interior mound.
 Group or village of cavate lodges.	 Inclosure with exterior mound.
 Subterranean lodge.	 Excavation.
 Group or village of subterranean lodges.	 Reservoir.
 Igloo lodge.	 Canal.
 Group or village of Igloo lodges.	 Copper mine.
 Inhabited stone village (Pueblo).	 Flint mine or quarry.
 Assembly lodge of wood.	 Soapstone mine.
 Assembly lodge of earth.	 Mica mine.
 Assembly lodge of stone.	 Cave deposit.
 Cliff assembly lodge.	 Cave burial.
 Cave assembly lodge.	 Refuse heap.
 Subterranean assembly lodge.	 Shell heap.
 Tower.	 Sculpture.
 Mound.	 Group of sculptures.
 Group of mounds.	 Petroglyph.
 Assembly mound.	 Group of petroglyphs.
 Effigy mound.	 Cache.
 Group of effigy mounds.	 Cairn.
 Domiciliary mound.	 Trail.

A work on archæology of which the year may justly feel proud is that of M. Emile Cartailhac upon the prehistoric age of Spain and Portugal, the result of a scientific mission under the patronage of the minister of public instruction of France. The Iberian peninsula is one of the most favored spots in the world for gaining a view of the whole

industrial history of humanity. Let us commence by following M. Rihiero, who in 1866 found in the tertiary beds of the valley of Otta white and colored quartzites, some showing that spalls had been knocked off, others worked or fashioned. These are described at length and figured by M. Cartailhac.

The paleolithic periods of the quaternary shell-heaps, the caverns and lake dwellings of the neolithic period, and the extraordinary structures of the bronze and early iron age, bridge over the time between the man of Otta and the historic period.

## BIOLOGY.

Professor Virchow reports in *Archiv für Anthrop.* (xvi, 275-475) the result of the investigation by the Anthropological Society of Germany on the color of the skin, the hair, and the eyes among school children. In the second meeting of this society (1871) at Schwerin a plan was adopted for collecting statistics of crania. The next year Dr. Ecker proposed the study of the size of the body and the color of hair and eyes. Finally, in 1873, Dr. Virchow proposed, at Weisbaden, the consideration of the subject of blondes and brunettes, through the schools. The following scheme was sent out:

School .....		
Description	Whole number.	Jews.
1. Blue eyes, blonde hair, white skin .....	.....	.....
2. Blue eyes, brown hair, white skin .....	.....	.....
3. Blue eyes, brown hair, brown skin .....	.....	.....
4. Gray eyes, blonde hair, white skin .....	.....	.....
5. Gray eyes, brown hair, white skin .....	.....	.....
6. Gray eyes, brown hair, brown skin .....	.....	.....
7. Gray eyes, black hair, brown skin .....	.....	.....
8. Brown eyes, blonde hair, white skin .....	.....	.....
9. Brown eyes, brown hair, white skin .....	.....	.....
10. Brown eyes, brown hair, brown skin .....	.....	.....
11. Brown eyes, black hair, brown skin .....	.....	.....

The result of the entire investigation is as follows:

	Number.	Per cent.
School children .....	6, 758, 827	.....
Jews .....	75, 377	1. 1
School children:		
Blondes .....	2, 149, 027	31. 80
Brunettes .....	949, 822	14. 05
Mixed .....	3, 659, 978	54. 15
	6, 758, 827	100. 00



	Number.	Per cent.
Jews:		
Blonde.....	8,421	11.17
Brunette.....	31,673	42.00
Mixed.....	35,283	46.83
	75,377	100.00
Hair:		
Blonde.....	4,617,546	68.02
Brown.....	1,988,966	29.48
Black.....	133,864	1.98
Red.....	17,499	0.25
Jews, hair:		
Blonde.....	24,154	32.03
Brown.....	41,025	54.39
Black.....	8,644	11.46
Red.....	319	0.42
Eyes:		
Blue.....	2,673,539	39.55
Brown.....	1,839,214	27.21
Gray.....	2,242,702	33.18
Jews, eyes:		
Blue.....	14,559	19.30
Brown.....	39,207	51.99
Gray.....	20,380	27.00
Skin:		
White.....	6,184,406	91.50
Brown.....	571,628	8.45

A series of volumes is being published in Paris entitled *Bibliothèque Ethnologique*. The first of this series printed in 1886, though bearing date of the following year, is by de Quatrefages, and bears the special title "Introduction à l'étude des races humaines." Though apparently a work on ethnology simply, it really covers the whole field of anthropology, as the following headings of chapters will show :

- (1) Règne humain. Does man form a kingdom of nature ?
- (2) Unity of the human species.
- (3) Origin of the human species.
- (4) Antiquity of the human species ; fossil races ; survival of fossil races.
- (5) Geographical origin of the human species.
- (6) The peopling the globe.
- (7) Acclimation of the human species.
- (8) Primitive man, antiquity of ethnic types.
- (9) Formation of human races.
- (10) General ethnic characteristics.
- (11) Physical characteristics.
- (12) Intellectual characteristics.
- (13) Moral and religious characteristics.

M. de Quaterfages gives the following scheme of knowledge with reference to the kingdom of man :

Empires.	Kingdoms.	Phenomena.	Causes.
Inorganic .. {	Sidereal.....	Keplerian movement.....	Gravitation.
	Mineral.....	Keplerian movement <i>plus</i> physico-chemistry.	Gravitation. Etherodynamics.
	Vegetable ...	Keplerian movement <i>plus</i> physico-chemistry <i>plus</i> vitality.	Gravitation. Etherodynamics. Life.
Organic .... {	Animal.....	Keplerian movement <i>plus</i> physico-chemistry <i>plus</i> vitality <i>plus</i> voluntary motion.	Gravitation. Etherodynamics. Life. Animal spirit.
	Human .....	Keplerian movement <i>plus</i> physico-chemistry <i>plus</i> vitality <i>plus</i> voluntary motion <i>plus</i> morality and religiosity.	Gravitation. Etherodynamics. Life. Animal spirit. Human spirit.

Being a pronounced monogenist the author brings his theory into contrast with that of the polygenists in the scheme.

MONOGENISM.

All men belong to one and the same *species*.

The differences which distinguish human groups are racial characters.

At what epoch did this single species appear on the surface of the globe? The question of antiquity is simple.

The human species first occupied only a circumscribed area of the globe. There is then a question of geographic origin to resolve.

The globe was peopled by migrations of which we have to search the traces and reconstruct the history.

To-day there probably exists no autochthonous people. America in particular and Polynesia were peopled only by colonists.

The human species inhabit to-day the entire globe, the pole as well as the equator.

POLYGENISM.

There are several *species* of men.

These differences are like specific characters.

At what epoch have appeared the different human species? Have they arisen simultaneously or successively? The question of antiquity is multiple.

The different species have first appeared on the spots where history announced their discovery. The question of geographic origin does not exist.

Migrations count for nothing in the general peopling of the earth. The question of primitive migration does not exist. The emigrations of which history has preserved the memory are exceptional and have exercised only an insignificant influence over the geographical distribution of peoples.

Excepting the European colonies founded in our day and those recorded in history, almost the entire globe has been peopled by autochthones. Specially, all the peoples of America and Polynesia were and could only be the products of the soil where modern explorers have found them.

The human peoples constituting so many species originating on the spot were made

tor. It has, therefore, subjected itself to the most diverse environments. The question of acclimation in its widest and in its most special sense is necessarily raised.

In these migrations the human species exposed to the action of new environments could but be modified. This explains the formation of a certain number of races. Facts of the same nature passing in our day ought to arrest in a special manner the attention of anthropologists.

Crosses between human races in the past have given rise to races whose origin has been revealed by mixed characters imprinted by the parent types. We have to search the ethnic elements combined in peoples of this class.

Crosses between human races most diverse take place under our eyes. They have given birth to population, which enlarges from day to day and becomes more and more developed. The study of these populations presents a double and serious interest in that it teaches us concerning the past and permits us to look into the future.

All present populations have been more or less modified, either by environments or by crossing. The primitive type of humanity is lost. Even did it now exist we could not recognize it in default of knowledge. Nevertheless, is it not possible to trace out some of the marks which would characterize it?

M. de Quatrefages justly draws attention to the fact that the argument between the monogenists and polygenists seems to leave out of view the fact that there may be different species of man and yet may have been only one original species. That is, in order to believe in more than one human species it is not necessary for one to be a polygenist.

Pietro Belsanti, in his work on "Progressive Characters of the Human Skull," examined fifty-two crania of anthropoids and two hundred and twenty of the lower races of men. Those studied were the following, for which the results are given:

1. Inferior human races.

Polyhedry accented, 197 in 220, or 89.5 per cent.

Nasal bones atrophied, 171 in 214, or 79.9 per cent.

Nasal spine atrophied, 141 in 216, or 65.2 per cent.

Alveolar arch in upsilon, 139 in 215, or 64.6 per cent.

Osseous crests well developed, 128 in 220, or 58.2 per cent.

Sutures simple, 119 in 210, or 56.6 per cent.

Pterion reflexed, 56 in 214, or 16.8 per cent.

Wormian bones pterique, 65 in 214, or 30.4 per cent.

Volumes of three molars enlarged, 10 in 113, or 8.8 per cent.

to live in the environments which encompass them. There is no general question of acclimating. We have only to study the special cases resulting from the expansion of modern population.

The different human species have appeared with all the characteristics now marking them. Change of environment could not alter these. We are not to search how these distinctive characters could be brought out.

Populations with mixed characters are, like the rest, distinct species and autochthonous. One need not disturb himself, therefore, about their pretended ethnic origins.

Crosses among human species can have no durable consequences. The resulting peoples would remain stationary or disappear if the crossing ceased. Their study possesses, therefore, no serious interest for us.

All the human species having appeared with their appropriate characters, such as we now recognize them, the problem of primitive man has no existence.

2. Anthropoid Apes.

- Polyhedry accented, 52 in 52, or 100 per cent.
- Alveolar arch in  $\epsilon$ , 52 in 52, or 100 per cent.
- Sutures simple, 26 in 28, or 92 per.
- Nasal bones atrophied, 47 in 51, or 92 per cent.
- Absence of nasal spine, 36 in 52, or 69.2 per cent.
- Osseous crests highly developed, 24 in 33, or 63.6 per cent.
- Pterion reflexed, 20 in 43, or 46.5 per cent.
- Among oranges, 8 in 31, or 26 per cent.

In the Index Medicus a special department is assigned to Hygiene, and the following analysis of that department will show how deeply rooted anthropology is becoming in the learned professions:

XIII. STATE MEDICINE.

1. *Medicine and medical ethics.*
2. *Hygiene and public hygiene.*
  - a. Construction and management of hospitals.
  - b. Heating and ventilation.
  - c. Hygiene of cities.
  - d. Hygiene of habitations.
  - e. Hygiene of occupations.
  - f. Hygiene of person.
  - g. Hygiene of schools.
  - h. Inspection and disposal of the dead.
  - i. Inspection of food and drugs.
  - k. Sewerage, drainage, and water supply.
3. *Medical education and schools.*
4. *Medical jurisprudence and toxicology.*
5. *Military and naval medicine.*

PSYCHOLOGY.

Dr. Alexander Bain read at the last meeting of the British Association, a paper on the scope of anthropology and its relations to the science of mind. Says this distinguished authority: "The mode of research grounded on discriminative sensibility, and working up from that, according to the best known principles of our intellectual nature may be contrasted with another mode which has always been in vogue, namely, finding out and noting any surprising feats that animals can perform out of all proportion to what we should be led to expect of them.

"The spirit of such inquiries is rather to defy explanation than to promote it. They delight to nonplus and puzzle the scientific investigator who is working his way upward by slow steps to the higher mysteries. Before accounting for the exceptional gifts of animals—the geniuses of a tribe,—we should be able to prove the average and recurring capabilities.

"It is an error to suppose the mental qualities do not admit of measurement. No doubt the higher complex feelings of the mind are incapable of being stated with numerical precision, yet by a proper mode of approaching the subject a very considerable degree of accuracy is attainable.



"As to the present position of the science of mind in the British Association, it is nowhere. Taken in snatches, it appears in several places; it would come in under zoology, which embraces all that relates to animals; under physiology, in connection with the nervous system and the senses, and it figures still more largely, although in an altogether subordinate and scarcely acknowledged fashion, in the section on anthropology. Indeed, to exclude it from this section would be impossible; man is nothing without his mind. Now, while zoology and physiology would keep the study of mind within narrow limits, there is no such narrowness in the present section. In the ample bosom of anthropology any really valuable contribution to the science of mind should have a natural place.

"Psychology has now a very large area of neutral (non-controversial) information; it possesses materials gathered by the same methods of rigorous observation and instruction that are followed in the other sciences. The researches of this section exemplify some of these. If these researches are persisted in they will go still further into the heart of psychology as a science and the true course will be to welcome all the new experiments for determining mental facts with precision and to treat psychology as an acknowledged member of the section. To this subdivision would then be brought the researches into the brain and nerves that deal with mental functions; the experiments on the senses having reference to our sensations; the whole of the present mathematics of man, bodily and mentally; the still more advanced inquiries relating to our intelligence; and the nature of emotion as illustrated by expression in the manner of Darwin's famous treatise. Indeed, if you were to admit such a paper as that contributed by Mr. Spencer to the Anthropological Institute you would commit yourself to a much further raid on the ground of psychology than is implied in such an enumeration as the foregoing."

Experimental psychology is the application of instruments of precision to human thinking and acting, and in the last few years has become one of the most fascinating branches of anthropology. Professor Wundt, in Leipzig, has pursued this study most systematically in a laboratory especially fitted up for the purpose. A quarterly publication, *Philosophische Studien*, is devoted mainly to publishing the work of this laboratory.

The studies relate to the powers of the mind in various directions, as memory, judgment, etc., but especially to the re-action time of various operations. Dr. J. M. Cattell, an American student, has examined this class of phenomena in three groups: (1) The re-action time, which is simply the time after the application of a sense stimulus necessary for an individual to record the fact that he has received the sensation; (2) the distinction or perception time, which is the additional time necessary for him to appreciate the nature of the sensation; *e. g.*, whether a light was red or blue; (3) the choice or will time, which is the additional time

necessary to react in a certain way on the reception of a certain sensation; *e. g.*, to press a key with the right hand when the red light appears, with the left hand or not at all for the blue light. The following summary gives results:

	Second.
Re-action time for light .....	.150
Perception time for light .....	.040
Perception time for a color .....	.095
Perception time for a picture .....	.105
Perception time for a letter .....	.120
Perception time for a short word .....	.125
Will time for colors .....	.340
Will time for pictures .....	.365
Will time for letters .....	.155
Will time for words .....	.105

The most extensive contribution is that of Dr. J. M. Cattell, recounting experiments made in the Psychological Laboratory of the University of Leipzig. (*v. Psychometrische Untersuchungen* [Doctor's Dissertation], von James McKean Cattell, pp. 72. Reprinted in Wandt's *Philosophische Studien*, III, 2 and 3, and abridged in *Mind*, 1886; *v.* also *Brain*). This observer has re-investigated almost the entire field; has improved the method of research, and introduced new variations in the experiments. (1) For simple re-action-times Dr. Cattell uses a magnetic falling screen which at a definite point in its fall reveals a card or a color, conveys a shock to the finger, or arouses any sense-organ that is desired; it simultaneously releases the magnet of a Hipp chronoscope (strictly regulated by finding the most suitable electric currents for its release), while the observer re-acts by closing a key, or speaking into a tube, which, like the hand-key, instantly stops the clock. The time to see daylight was found quite constant and  $151\sigma$  ( $\sigma = \frac{1}{1000}$  of a second) in one observer,  $147\sigma$  in the other, if the hand-key is used indifferently with the right or left hand; the lip key takes  $30\sigma$  longer. He can also measure how long a color, etc., must be seen to make any impression; this latent time is for orange,  $.8\sigma$ ; yellow,  $1\sigma$ ; blue,  $1.2\sigma$ ; red,  $1.3\sigma$ ; green,  $1.4\sigma$ ; violet,  $2.3\sigma$ . Distracting the attention by disturbing sounds had little effect on the time, which unusual result is explained by the great automaticity of the process. Adding numbers lengthens the time; extreme attention maintainable for only one second shortens it. (2) Perception-times. The *additional* time necessary for recognizing whiteness and sending out the voluntary impulse was for the two observers  $61\sigma$  and  $95\sigma$ , which time is divided equally between the two operations, as in (1) the closing of the key was automatic. To see that a color is or is not black requires a slightly longer time. To distinguish one of *two* colors required 100 and  $110\sigma$  in the two observers; one of ten colors, 105 and  $117\sigma$ . It thus takes  $5.8\sigma$  longer to distinguish one of ten than one of two colors, but  $33\sigma$  longer to say what the color is than that it is not black. For two letters the time is lengthened by

38 $\sigma$ . E is the most difficult letter to read; M A Z B E was the order of ease in the five letters used. The time for short English words was 142 $\sigma$ , being slightly longer for longer or for foreign words. The word is the reading unit, requiring only a slightly longer time for its recognition than for that of a single letter. It takes less time to recognize a small picture than a short word. (3) Choice-time. To act with the right hand for one color, and with the left for another, lengthens the time by 26 $\sigma$ . To re-act by naming (*i. e.*, reading) a letter requires 400 $\sigma$ ; a one-place numeral 360 $\sigma$ , 393 $\sigma$  for a two-place, and 418 $\sigma$  for a three-place, the increase in time diminishing. It takes longer to read (not pronounce) long than short, foreign than vernacular words. It actually takes only 111 $\sigma$  or 50 $\sigma$  less to name a short word than a letter, indicating the closeness of the association between the name and the word. A color is seen quickly, but to name it requires 343 $\sigma$ ; a picture can be named in about equal time. By way of summary we have:

Re-action time for light.....			$\sigma$	150
Perception-time for light.....	40		$\sigma$	
Perception-time for color.....	95	Choice-time for color.....		340
Perception-time for picture.....	105	Choice-time for picture.....		365
Perception-time for letter.....	120	Choice-time for letters.....		155
Perception-time for (short) word...	125	Choice-time for words.....		105

Dr. Cattell also shows that extreme attention can shorten central processes; that the effect of practice is marked at first, but soon reaches a limit as automatism sets in; that fatigue is not so easily induced or so disturbing as usually thought. In a later research (Mind, January, 1887) he adds the following: To give the name of the picture of an object in a foreign language (English for German, and *vice versa*) took 649 $\sigma$  and 694 $\sigma$ , respectively, or 172 $\sigma$  and 149 $\sigma$  longer than in the vernacular. This suggests a mode of gauging one's acquaintance with a foreign tongue. It similarly takes longer to translate from the foreign to the vernacular than the reverse. Given a city to name the country in which it is situated required 400 $\sigma$ ; given a month to name the following month, 367 $\sigma$ ; to name the preceding month, as much as 798 $\sigma$ . Given a month to name its season, 363 $\sigma$ ; the reverse, 498 $\sigma$ ; showing that it is easier to go from part to whole than the reverse. To give an action for a substantive (*e. g.*, *swim-fish*), 646 $\sigma$ ; an object for a verb (*write-letter*), 517 $\sigma$ . To judge the length of a line took nearly one second. In general the closer the association the shorter the time; and the more complex the operation the greater the individual variation.

Tambroni and Algeri observed (1) the time of feeling a contact on the skin; (2) the time of feeling whether a single point or two points 2.2<sup>mm</sup> apart was drawn across the tip of the right forefinger in patients suffering with various kinds of insanity. The paranoiac re-acts more quickly, all other forms of alienation more slowly, than normal. When the normal



time is  $183\sigma$  the paranoiaced time is  $174\sigma$ , the maniacal type is  $312\sigma$ , the demented  $344\sigma$ , the epileptic  $362\sigma$ , the melancholic  $374\sigma$ —a very suggestive table.

Guiccardi and Cionini studied the effect of repetition in shortening the time of simple acts, and conclude that the more complicated the act the greater abbreviating power has repetition. A simple touch re-action was shortened  $18\sigma$  by 250 repetitions; distinguishing that a single point was in contact by  $121\sigma$ ; the time of writing three letters by  $1,956\sigma$  in 500 repetitions; in associating a word, a difference of nearly five seconds between the shortest and longest.

Dr. Joseph Jastrow (Science, September 10, 1886, Proceedings of the American Association for the Advancement of Science, xxxv, p. 272) proposes a simplification of the methods of measuring simple re-action time, distinction time, choice time, and association time that dispenses with all apparatus except a watch, packs of cards, and slips of paper, and is well suited for a class demonstration. The principle throughout is to have a *continuous series* of the processes, the time of which is to be measured, and by dividing, to get the time of a single act. For *simple re-action-times* a circle of persons touch hands, and the time it takes for a pressure to pass around the circle divided by the number of persons (after considerable drill) gives a normal re-action time. [This was previously suggested by Dr. O. W. Holmes.] The *perception time* is measured by the difference in time necessary to throw down a pack of cards one by one, and the time necessary to notice the color, suit, or the like while throwing. The cards must be held with the backs towards the subject. The *additional choice time* is gotten by subtracting the unreduced perception-times from the time needed for sorting the cards into heaps according to suit, color, and so on. For the *association time* you first get the sum of the association-times of two observers by subtracting (*a*) the time for each to call a certain number of words from (*b*) the time for one to call a word to which the other replies with an association-word, and in turn gives a call-word to the first, etc., and then group a third person with each of the two in the same process. This gives six equations, from which all the values may be ascertained. The method is found to be satisfactorily accurate and admits of much variation and adaptation.

Mr. Francis Galton (A descriptive list of Anthropometrical Apparatus) describes an instrument which by the release of a falling rod on the presentation of the stimulus (to eye, ear, or touch), and by its being caught again when the subject re-acts to the signal, measures simple re-action-times very conveniently and without the need of an assistant.

In announcing the publication of a journal of psychology, Prof. G. Stanley Hall outlines the study as it now stands in the minds of advanced anthropologists.

The records of psychological work of a scientific as distinct from a



speculative character have been so widely scattered as to be largely inaccessible save to a very few, and often to be overlooked by them. Several departments of science, often so distinct from each other that their contributions are not mutually known, have touched and enriched psychology, bringing to it often their best methods and their ripest insight. It is from this circumstance that the vast progress made in this department of late years is so little realized and that the field for such a journal is so new and the need believed to be so great. The journal will contain original contributions of a scientific character. These will consist partly of experimental investigations on the functions of the senses and brain, physiological time, psychophysics law, images and their association, volition, innervation, etc., and partly of inductive studies of instinct in animals, psycho-genesis in children, and the large fields of morbid and anthropological psychology, not excluding hypnotism and the field vaguely designated as that of psychic research; and lastly, the finer anatomy of the senses and the central nervous system, especially as developed by the latest methods of staining, section, etc.

#### ETHNOLOGY.

*Ethnology and nationality.*—The testimony of ethnology is invoked by diplomatists with reference to European boundaries and politics, notably in the settlement of the Turkish problem. What are the boundaries of nationality? To this question various answers have been given.

- (1) A nation is an *ensemble* of people under the same government.
- (2) A nation is all the inhabitants of the same region.
- (3) A nation comprises all who speak the same language.
- (4) A nation includes people of the same race.

At present, says Mr. Topinard, the living question is the principle of nationality resting upon race, words of pleasant sound which flow gracefully from the pen of the daily journalist. The same writer utters a timely caution against the excessive application and draws attention to the complicated elements which go to make up that community of right and interest called a nation. (Rev. d'Anthrop., 3 s., 1, 24.)

Major Powell, in the preface to the fourth annual report of the Bureau of Ethnology, divides the work of his bureau into three classes:

- (1) A series of charts showing the habitat of all tribes when first met by Europeans and at subsequent eras.
- (2) A dictionary of tribal synonymy, which should refer the multiplied and confusing titles, as given in literature and in varying usage, to a correct and systematic standard of nomenclature.
- (3) A classification on a linguistic basis of all known Indians of North America (remaining and extinct) into families or stocks.

*Relationships between Eskimo tribes.*—Dr. Rink gives a short paper in Journal of the Anthropological Institute on the relationship of the

Eskimo tribes as determined by dialects. The following table illustrates the order of thought:

Aboriginal inland Eskimo.

Principal stem, Eskimo proper.		Side branch, Aleutians.	
Eastern.		V. Western.	
III. Middle regions: Iglulik, Repulse Bay, Churchill.	IV. Mackenzie.	Northern.	Southern.
		1. Pt. Barrow. 2. Kaviagmut. 3. Malemut. 4. Unaligmut. 5. Ekogmut. 9. Asiatics.	6. Tschugazzet. 7. Kadjagians. 8. Kangengdlit.
I. Greenlanders.	II Labradorians.		

TECHNOLOGY.

Technology, in the anthropological sense, is the natural history of human arts. Whatever men habitually think about gives rise to specific industries and arts. The study of the progress of mind through these arts is a proper study for anthropologists.

An excellent example of research in this direction is afforded by Mr. Holmes's papers on pottery in Major Powell's fourth annual report—notably by the one on the origin and development of form and ornament in ceramic art.

Forms of pottery arise as follows:

Origin of form	by adventition	{ of natural models of artificial models
	by imitation	
	by invention	

Modification of form may arise in many ways:

Modification of form	{	by adventition	incapacity	{ to assume form to retain form
			incapacity of the artisan	
			changes of method in manufacture	
			changes of environment	
	{	by intents	changes of use	{ for the beautiful for the grotesque
			lack of use	
			influence of men or exotic forms	
			to enhance usefulness	
	{	to please fancy		

Mr. Holmes classified decorative motives as follows:

Suggestions of features of natural utensils or objects

Origin of ornament	{ suggestions of features of artificial utensils or objects	{	functional	{ handles
				{ legs
			constructional	{ bands
				{ perforations
Suggestions from accidents attending construction	{	{	{	{ the coil
				{ the seam
				{ the stitch
				{ the plait
	{	{	{	{ the twist, etc.
				{ marks of fingers
				{ marks of implements
	{	{	{	{ marks of models, etc.

*Suggestions of ideographic features or pictorial delineation.*—Professor Morse's Japanese Homes is an excellent example of the application of scientific methods to a human art. Among the elaborations of culture the habitation has kept itself steadily in harmony with progress, climate, material, and the ruling ideas of different peoples. A description of the houses and house-life of the races of men would furnish abundant material for the reconstruction of past history in that regard.

Prof. E. S. Morse has made the method of arrow-release throughout all times and places a subject of ethnic study. Proceeding to trace the migrations of men by the movements of a habit, the methods of release are as follows:

(1) *Primary*.—The nock of the arrow is grasped between the end of the straightened thumb and the first and second joints of the bent fore-finger. It is practiced by children universally, and by the Ainos, Demeraras, Utes, Navajos, Chippewas, Micmacs, Penobscots.

(2) *Secondary*.—The nock of the arrow is grasped with the straightened thumb and bent fore-finger, while the ends of the second and third fingers are brought to bear on the string to assist in drawing. It is practiced by Zuñis, Chippewas of Wisconsin, Ottawas.

(3) *Tertiary*.—In this release the fore-finger, instead of being bent, is nearly straight with its tip as well as the tips of the second and third fingers, pressing or pulling on the string, the thumb, as in the primary and secondary release, active in assisting in pinching the arrow and pulling it back. It is practiced by Sioux, Arapahos, Cheyennes, Assiniboinis, Comanches, Crows, Blackfeet, Navajos, Siamese, Great Andamanese.

(4) *Mediterranean*.—The string is drawn back with the tips of the first, second, and third fingers, the balls of the fingers clinging to the string with the terminal joints of the fingers slightly flexed. The arrow is lightly held between the first and second fingers, the thumb straight and inactive. Practiced by nations around the Mediterranean, by modern archers, Flemish (using first and second fingers only), Eskimo, Little Andamanese.

(5) *Mongolian*.—In this release the string is drawn by the flexed thumb bent over the string, the end of the fore-finger assisting in holding the thumb in position. The thumb is protected by a guard of some kind. It is practiced by Manchus, Chinese, Koreans, Japanese, Turks, Persians.

#### COMPARATIVE PHILOLOGY.

Colonel Mallery's paper on the pictographs of the North American Indians fills a gap in the study of the natural history of languages. In a former paper he discussed the gesture-language as perhaps the earliest method of thought-transference. In the author's own words, "a pictograph is a writing by picture." The execution of the pictures of which it is composed often exhibits the first crude efforts of graphic art. When

pictures are employed as writing the conception intended to be presented is generally analyzed, and only its most essential points are indicated, with the result that the characters when frequently repeated become conventional, and in their later forms cease to be recognizable as objective portraitures.

A striking example of the interdependence of language and arts is afforded by Mr. Cushing's paper on Pueblo pottery. Following up Mr. Holmes's investigations into the origin of decoration, the author finds that these theories are justified by an intimate study of language. Indeed, the names of certain forms of pottery and decoration as well as of building do not refer to the things as they now exist, but are the veritable designations of things and forms out of which the modern forms are thought to have sprung.

*Origin of languages.*—The vice-presidential address of Hon. Horatio Hale before Section H of the American Association at Buffalo was upon the origin of languages and the antiquity of speaking man. It contains views so original and novel that it is eminently proper to present a condensed scheme of the argument.

Among the puzzling questions in anthropology which we are bound to notice are these two: When did linguistic stocks originate? When did man acquire the faculty of speech? It will be seen that the origin of languages and the origin of language are two very different questions.

Mr. Hale, rejecting the old theories which rely upon time, the dispersion of a monosyllabic parent stock, or the dispersion of speechless man, and the origination of languages in different centers, avers that the origin of linguistic stocks is to be found in what may be called the language-making instincts of very young children. To insure the creation of a speech which shall be the parent of a new linguistic stock, all that is needed is that two or more young children should be placed by themselves in a condition where they will be entirely, or in a large degree, free from the presence and influence of their elders, and that they should continue in this condition long enough to grow up and form a household, and to have descendants to whom they can communicate their new speech.

This theory is elaborated with great care, and the multiplicity of stocks in California made a camping-ground of the argument.

The second part of the argument is also accompanied with the revival of startling doctrines, namely, that while the antiquity of man is incalculable, the speaking man is of recent origin, having occupied this planet not over ten thousand years at most.

If we are willing to give the name of man to a half-brutish being, incapable of speech, we must allow to this being an existence of vast and as yet undefined duration, shared with the mammoth, the woolly rhinoceros, and other extinct animals. But if we term the beings of that race the precursors of man and restrict the name of man to the members of the speaking race that followed them, then the first appearance of man,



properly so styled, must be dated at about six thousand or ten thousand years ago. And this man who thus appeared was not a man of feeble powers, a dull witted savage. He possessed and manifested from the first intellectual faculties of the highest order, such as none of his descendants have surpassed. His speech, we may be sure, was not a mere mumble of disjointed sounds; it was a full, expressive, well-organized speech, complete in all its parts. The first men spoke because they possessed along with the vocal organs the cerebral faculty of speech; "that faculty was an instinct of the mind, as irresistible as any other instinct."

#### MYTHOLOGY AND FOLK-LORE.

The folk-lorists of England have been wrestling for the last three years with the following questions:

(1) The definition, the inclusions and exclusions of the term folk-lore.

(2) The establishment of classic concepts for the material included. It is very easy to say, put things together that are alike, but it is most difficult to settle upon that characteristic of likeness which will combine our examples into what may be called natural genera, species, etc. Connected with this idea of classic concepts is the associated one of terminology.

(3) The anatomy of tales, customs, practices, etc., and the invention of a glossary of their organic parts, their *dramatis personæ*, their essential incidents.

In vol. III of the Folk-lore Journal (pp. 1-16), Mr. G. L. Gomme undertakes to answer these questions. He had previously in (vol. II, pp. 287, 311) advocated a systematic effort of folk-lorists in the same direction. A few definitions are given below to indicate the mental drift of the gentlemen interested:

"Folk lore is anthropology dealing with primitive man." (Alfred Nutt.)

"Folk-lore is anthropology dealing with the psychological phenomena of uncivilized man [meaning unlettered as well as savage], and embraces both folk-thought and folk-wont" (practice). (E. Sidney Hartland, Folk-l., II, 340.) "That portion of anthropology which deals with the psychological phenomena of primitive man." (C. Staniland Wake, Folk-l. J., II, 345.)

"Folk-lore is the unwritten learning of the people. Folk-lore is not a science; it is the thing itself. One of the chief objects of the collection and arrangement of the facts of folk lore is to generalize and philosophize; but the generalizations which we arrive at will not be folk-lore." (Henry B. Wheatley, Folk-lore J., II, 347.)

"Folk-lore deals primarily with the survival of primitive customs and beliefs among civilized races, and is comparable with, not identical with, the living primitive customs and beliefs of savage races. The sanction back of folk-lore is tradition. Folk-lore is the science which treats of the survivals of archaic beliefs and customs in modern ages." (G. L. Gomme, I c. III, 14.)

"Folk-lore, 'the folk's learning;' all that the folk believe or practice on the authority of inherited tradition and not on the authority of written records." (Charlotte S. Burne, Folk-lore J., III, 103.)

"Folk-lore is the science which has for its object the study of undifferentiated or anonymous humanity from an epoch which may be considered its infancy down to our own day." (Antonio Wachado y Alvarez, Folk-lore J., III, 113.) This whole essay must be read. One can not afford to omit a sentence.

"Folk-lore is knowledge of folk-life or the life of uncultured classes, as distinguished from culture lore, knowledge of individualized life, the life of the cultured classes, and the generalizations arising from these two knowledges or the sciences of folk-life and of culture-life are complementary and mutually corrective divisions of the same mental and moral sciences, the historical sciences, namely, or mental development and of civil progress." (T. S. Stuart Glennie, Folk-lore J., IV., 75.)

We come now to the second series of questions, the subject of classic concepts, the study of "What should go where," as Miss Charlotte S. Burne happily puts it.

Mr. E. Sidney Hartland divides folk-lore into two departments, *folk-thought* and *folk-practice*, or, still better, *folk-wont*. I like folk-wont for the reason that folk-lore does not so much include practice. For instance, I may tell you how an arrow-maker or potter produces his ware, and do it so graphically that a mechanic may counterfeit them. But I have omitted the thousand and one dispensables which the lowly artisan considered indispensable, leaving them for the folk-lorist to glean.

Folk-lore is thus divided:

1. Folk-thought: (1) tales of all kinds, sagas (world-god, hero, elf, ghost-sagas, etc.), nursery tales, drolls, cumulative tales, apologues; (2) folk-songs; (3) weather-lore; (4) proverbs; (5) local and personal saws and prophecies; (6) riddles; (7) folk-speech.

2. Folk-wont: (1) worship, every practice designed to propitiate the powers influencing man's destiny; (2) folk-law; (3) folk-leechcraft; (4) games; (5) folk-craft.

Mr. Gomme gives the following scheme:

1. Traditional narratives: (a) folk-tales; (b) hero-tales; (c) ballads and songs; (d) place legends.

2. Traditional customs: (a) local customs; (b) festival customs; (c) ceremonial customs; (d) games.

3. Superstitions and beliefs: (a) witchcraft; (b) astrology; (c) superstitions, practices, and fancies.

4. Folk-speech: (a) popular sayings; (b) popular nomenclature; (c) proverbs; (d) jingle rhymes, riddles, etc.

This is amended by Miss Charlotte S. Burne as follows:

Group 1. Traditional narratives: class a, folk-tales; class b, hero-tales; class c, ballads and songs; class d, place legends and traditions.

Group 2. Superstitions, beliefs, and practices: class *a*, goblinom; class *b*, witchcraft; class *c*, astrology; class *d*, superstitions connected with material things.

Group 3. Traditional customs: class *a*, local customs; class *b*, festival customs; class *c*, ceremonial customs; class *d*, games.

Group 4. Folk-sayings: class *a*, jingle, nursery rhymes, riddles, etc.; class *b*, proverbs; class *c*, old saws, rhymed and unrhymed; class *d*, nicknames, place rhymes and sayings, folk-etymology.

Mr. J. S. Stuart Glennie divides the study of man's history into that of folk-lore and of culture life. The classification of folk-lore is identical with the psychological elements of folk-life corresponding (A) with the most general facts of human consciousness: (1) an external world, (2) other beings, (3) an ancestral world; (B) and with the most general facts of human faculty: (1) imagination, (2) affection, (3) memory. Corresponding with these facts of consciousness and of faculty the three psychological elements of folk-life are (1) folk-beliefs, (2) folk-passions, (3) folk-traditions, and the expressions of these are to be found in (1) customs, (2) sayings, (3) poesy. Folk-customs, as expressive of folk-life, may be more especially expressive of folk-belief or of folk-passions or of folk-traditions, and hence folk-customs may be classified as (1) festivals, (2) ceremonies, (3) usages (religious, sexual, and social). Folk-sayings may be classified as (1) recipes (magical, medical, and technical), (2) saws (proverbs, tests, riddles), (3) forecasts (omens, weather signs, and auguries). Folk-poesy may be classified as (1) stories, (2) songs (mythological, affectional, and historical), and (3) sagas.

Elements of folk-lore and subjects of folk-lore: (1) Folk-beliefs, (2) folk-passions, (3) folk-traditions.

The expressions of folk-life and records of folk-lore: (1) folk-customs, (2) folk-sayings, (3) folk-poesy.

1. Festivals ....	{ (1) Religious. (2) Sexual. (3) Social.	1. Recipes ..	{ (1) Magical. (2) Medical. (3) Technical.	1. Stories ..	{ (1) Mythological. (2) Affectional. (3) Historical.
2. Ceremonies ..	{ (1) Religious. (2) Sexual. (3) Social.	2. Saws ....	{ (1) Proverbs. (2) Tests. (3) Riddles.	3. Sagas —	{ (1) Meters. (2) Melodies. (3) Instruments.
3. Usages .....	{ (1) Religious. (2) Sexual. (3) Social.	3. Forecasts	{ (1) Omens. (2) Auguries. (3) Weather signs.	Folk- music.	

We are not prepared to accept Mr. Glennie's dictum that folk-lore is our lore about the folk, for that would really be culture lore, according to his own definition. Several of the gentlemen have wisely started their study with the two inquiries, Who are the folk and what is lore? Señor Alvarez remarks, "The word *folk*, German *volk*, Latin *vulgus*, Italian *volgo*, Sanish *vulgo*, signifies not the whole of humanity, but a portion of the human race, who possess a series of common signs, and are really anonymous in contradistinction from that other series of men who possess a notable personality." He would include practically all

savages and the untutored herd of civilized society. It is very certain that what constitutes the knowings, the sayings, and the ways or wonts of the untutored, the unthinking, and the unprogressive among us, remind us much of savagery. It is also very certain that each age of the world, each gradus of society, resembles the geological ages; that is, each one in addition to all that it has added of new, embraces or includes much of all the antecedent ages, grades, or epochs. The folk-lorists are, therefore, altogether scientific in collecting the lore of savages *en masse*, the lore of barbaric and civilized peoples, so far as they are survivals of times not their own.

Practically, therefore, what do the folk-lorists wish us to collect, and how shall we name and classify our material after it is gathered? Just at this writing we are inclined to use Miss Burne's modification of Mr. Gomme's scheme. For the filing of tales the folk-lore society has adopted a scheme with printed headings as follows:

1. Generic name of story (not to be filled up).
  2. Specific name.
  3. *Dramatis personæ*.
  4. Thread of story.
  5. Incidental circumstances.
  6. Where published.
  7. Nature of collection.
    - (1) Original or translation.
    - (2) If oral, state narrator's name.
    - (3) Other particulars.
  8. Special points noted by the editor of the above.
- (Signed) \_\_\_\_\_.

Including all human thought and wont, or creed and cult respecting the spirit world under the term religion, we necessarily view the medicine man of savages as a priest rather than as a physician. It is hard to tell whether in America or in Australia more is being done to understand the social and intellectual condition of the aborigines.

The men and women who in lower tribes stand for the clergy, as distinguished from the laity, or uninitiated, are variously styled doctors, wizards, or witches, sorcerers, seers, or prophets, mediums, soothsayers, necromancers, rain-makers (better weather makers), magicians, augurs, fortune tellers, enchanters, priests, personators, diviners, etc.

Now, these can readily be divided into two classes or functions, viz, those who see into, understand, and reveal the spirit world; and those who have more or less control over it, compelling it to do their bidding.

The medicine man, doctor, sorcerer, wizard, fetish man are all of the latter class. Whatever disease and death may be, whether merely the person or spirit of some noxious thing, or an independently existing spirit, one of the powerful charmers can induce or compel it to do his bidding, either by direct command, or by some diplomatic action called magic.



In the collection of material for a scientific investigation of this class of persons I have found it convenient to adopt the following questions:

(1) What are the actors called and what social rank do they hold?  
 (2) By what rites or initiations do they attain to the privileges of their class?

(3) What do they profess to do? What are they believed to be able to do? That is, to which class above named do they claim to belong?

(4) What do they actually perform? What is their mode of treatment? Do they sing, dance, go into ecstasy, suck the wound, spit out the disease in the form of a bone, stone, etc.? That is, not what they claim to do, but what do they, actually? What dress, paraphernalia, implements, and dramatic performances do they resort to? What fees do they charge?

(5) What is the area of their operations, both in the spirit and in the mundane world? Some cause, others cure, disease. Some have influence in one sphere, others in other spheres of spirits. Again, some operate on the sick, others on the conjured, lovers, lost cattle, epilepsy, etc.

(6) Folk-lore, beliefs, and customs of the folk in view of the foregoing subjects of inquiry.

A significant fact in the progress of science is the establishment of a professorship of the science of religion in the *École des Hautes Études* at Paris, in the University of Rome, under the auspices of the Italian Government, and at Brussels.

It is worthy of remark that such savants as Derenbourg, Rosny, Havet, Vernes, Libanea, and d'Alviella have charge of these courses.

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## MISCELLANEOUS ANTHROPOLOGICAL PAPERS.

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### AN INDIAN MUMMY.

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By JAMES LISLE, *Long Pine, Nebraska.*

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West of Fort Casper, in central Wyoming, is Poison Spider Creek, a tributary of the North Platte River. The valley of this stream is bounded on the northwest and north by a ridge of sand-rock, forming the water-shed.

In places this rises precipitously to the height of 40 to 50 feet, with a width at the top of 100 to 300 feet. Elsewhere the rock barely shows at the surface. In a cave in the west face of one of these precipices was found by S. D. Helm and D. W. Moffatt, the mummified body of an Indian. The cave is open to the weather—a mere recess about 14 feet long, 7 feet high, and 8 feet deep. Inside this is a second cave or recess, the floor of which is about  $2\frac{1}{2}$  feet above the main floor. This recess is about 7 feet long, 4 feet high, and 4 feet deep. The whole opening is natural.

The body, evidently that of some important personage, was placed in the inner cave in a kneeling posture, quite erect, with a very slight bend at the hip-joints to balance. The head is thrown well back, the chin high, and both head and face turned a little to the right. The hands are joined across the bowels, the right hand outermost. The face was to the front, looking westward. Originally there must have been some kind of stay or prop to support the body in its position, but this had long since disappeared, and the body had fallen to the left, the limbs and feet being slightly twisted in consequence.

The clothing was entirely rotted away, except fragments under the bracelets; the bits remaining here are of cotton. A leather belt, much decayed, is around the loins. Around each wrist is a coil of brass wire, forming a bracelet. That on the left wrist makes forty to fifty turns and extends about 6 inches. On the right wrist the coil is about 2 inches shorter. On the fingers are several coarse brass rings. In the ears are rings made of brass wire, the metal being very much corroded.

Around the neck is a necklace or collar made of pieces of quills cut from the wing-feathers of some large bird. The pieces are about an inch long, and the size about that of the wing-quills of a chicken. There is no pattern proper. The pieces extend lengthwise of the collar, about ten of them being placed side by side, making the width of the collar, about  $2\frac{1}{2}$  inches. Underneath this collar is another of similar workmanship considerably decayed. No weapons were found save pieces of nine or ten arrows, some with metal points, the others pointed with flint. Fragments of a bridle and saddle were found, the leathered work reduced to dust. The bridle-bit was a very primitive affair, but apparently made by a white man. The saddle was of Indian workmanship—a sort of “tree” made of bones. The man was of middle height and fifty to fifty-five years of age at his death. His hair, which is about 15 inches long, is slightly streaked with gray in front. He evidently died of an acute disease, since there is no sign of wasting sickness nor of bodily injury. The body was not embalmed nor was any special effort made to preserve it. The brain and internal organs have not been touched, the preservation of the body being due to the climate, aided to some extent possibly by chemical agencies within the cave itself (in places in the reef near by, the rocks are impregnated with petroleum, etc.). The flesh has dried up and shrunken to the bones. The weight of the body is about 25 pounds.

## MOUND IN JEFFERSON COUNTY, TENNESSEE.

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By DR. J. C. McCORMICK, *Strawberry Plains, Tennessee.*

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The mound of which this paper is the subject is on the left or east bank of the Tennessee River (Holston) 4 miles north from Strawberry Plains, Jefferson County, Tennessee. It is much larger than any other in this valley. It is about 30 yards from the river's bank, and its remarkable size and well-defined contour is such as will attract the attention of the most casual observer. Flints, broken stone, shells, and pieces of broken pottery all attest that it is the work of the mound-builders. The river at this point follows a course south 20 degrees east. No ditches or signs indicating that this mound was used as a place of defense are visible. Had these formerly existed the continued cultivation of the land for so great a period would most assuredly have obliterated them.

The mound is circular in outline, and is, properly speaking, an earthen burial mound. No stones of any size or in any considerable number were used in its construction. In the immediate vicinity are the remains of broken bowlders, but they do not occur in great numbers, neither do they enter into the "make-up" of the mound. In outline the mound is nearly a perfect circle. Measured from the base on one side to a corresponding point on the opposite side, on a horizontal plane, it is 120 feet in diameter. Its present diameter is somewhat greater than when completed. This is easily explained when we take into consideration the repeated plowings it has from time to time received for a century. Aside from this, the wearing and washing away produced by natural causes were sufficient to increase its natural diameter to a slight extent, while its perpendicular height has been greatly reduced. Its present height is 12 feet.

On Tuesday, November 2, 1886, I began an exploration of the mound. A trench was dug on a level 3 feet above the bottom of the mound. This trench extended in a direction north and south through the mound and was about 5 feet wide. Another trench of like dimensions and on the same level was begun on the west, and carried forward to a point where it intersected the trench running north and south. At a point near the junction of these, and 3 feet below the surface, was found the first skel-



eton. It had been buried with the head toward the east; had evidently been placed upon its right side, the face toward the north. The thigh bones were to some extent flexed upon the body, and the arms had been placed in front of the body and were somewhat extended. The cranium, teeth, tarsal, and metatarsal, carpal and metacarpal bones were in a fair state of preservation. No relics were found with this individual. Further exploration led to the discovery of five other skeletons during the day. These were found with their heads towards the east. Beads were found, and from their position it is evident they had been worn around the neck. During the day a skeleton was discovered near the apex of the angle formed by the south and west trenches.

On the second day the first skeleton observed was that of a child, evidently less than two years old. It had not passed the period of first dentition. The cranium was broken down and decayed to such an extent as to render any measurement of it utterly impossible. Of the long bones, the following linear measurements were taken at the time: Femur, 8.12-inches; tibiae, 6.62 inches; humerus, 6 inches; radius, 4.55 inches. The others were in a very bad state of preservation and accurate measurement was impossible. Another skeleton, that of a large sized individual, presented some interesting peculiarities. The skull of this skeleton was the first part met with in the process of unearthing. The bones of the cranium were in a fair state of preservation, as were those comprising the vertebral column and those of the upper extremity. The pelvic bones, also, were almost entire; but on searching for the bone of the thigh I was somewhat surprised when, after a careful search, only a small portion of the right femur was discovered. The remaining bones of both the lower limbs were entirely missing. That portion of the right femur exhumed presented all the characteristic signs of diseased bone, and the individual to whom it belonged had evidently been the subject of necrosis. It is not unfair, neither is it unreasonable, to assert that this disease prevailed among the mound builders as well as among races of mankind at the present day. But what was most perplexing was the absence of the other bones belonging to the lower extremities.

Of the remaining fifteen skeletons that were removed from the mound during the three days of my exploration, there was not one that presented this peculiarity. In *all* of them the bones of the lower extremities, or at least some portions, were found. Six skeletons were taken from the mound during the second day. Among this number were several in which some of the bones were in a good state of preservation. One of these gave the following measurements: Cranium, vertical height inside, 4.90 inches; occipito-frontal arch, 13.50 inches; parietal diameter, 6 inches; horizontal circumference, 20 inches; length, 7 inches; length of femur, 18.50 inches; length of tibiae, 15 inches; tibial circumference in middle, 3.75 inches; tibiae, least circumference, 3.25 inches; humerus, 12.85 inches; radius, 10.12 inches; clavicle, 6.25 inches.

Four skeletons were found during the third day. My assistant while removing one of them found a pipe and gorget that had been placed in front of it. The gorget is a circular disk 4 inches in diameter. It is made from a large and heavy shell. Both sides have been smoothly dressed, but are now somewhat roughened and stained, no doubt by the action of the soil in which it has lain. There are two perforations near the margin of the disk. They are considerably worn, thus indicating its long-continued use. The convex surface is plain and presents nothing for examination worthy of mention. The lines are well defined, and are clearly and deeply cut. The design is no doubt intended to represent a bird; in fact, the profile is plainly to be seen. Its resemblance to the cedar bird, *Ampelis cedrorum*, is very marked. The eye is represented by a small circle; within this there is a small depression or pit that is intended to represent the iris. The mandibles are short and conical in outline. A pointed crest that arises from the back of the head is plainly discernible. The incisions are clearly and cleanly traced, and the entire design exhibits the skill of the mound builder artist in a remarkable degree.

Among the objects obtained from the mound were several hundred beads of various sizes. The greater number of these are made of shell; some are of bone. Many are in a good state of preservation. Several flints were found that had apparently never been used, as their sharp edges and points would seem to indicate. Three whole vessels were taken from the mound. Several small disks of shell were found; these presented no particular ornamentation that is worth mentioning. Two pipes were recovered; these were uninjured and are without ornamentation. Three implements of bone are smoothly and evenly finished. They are hollow throughout their entire length. They are bevelled on one side for about half their length, and near the circular end there is a perforation on one side extending to the cavity within. They are no doubt made from the tibias of some animal, perhaps that of a deer. In addition to those already mentioned, there were found several pins, awls, and stones of various shapes and sizes.

In structure the mound consists of alternate layers of clay, sand, and ashes, varying in thickness, the material of which was probably obtained near by. The clay used in the construction of the mound was most likely taken from the river bank. Sand is found along the river. Stone was not used in the construction of this mound. Both land and fresh water shells are found scattered throughout its extent. The fresh water species largely predominate. Among them are found *Helix spinosa*, *H. alternata*, *H. appressa*, *H. elevata*, *Campeloma ponderosa*, *C. decisa*, *Io spinosa* (the latter abundant), *Angetrema verrucosa*, *Pleurocera anthonyi*, *P. filum*, *Anculosa praeiosa*, *Unio verrucosus*; besides many others which I am unable to determine.

Sixteen skeletons were taken from the mound. Of the crania, several were saved in fair condition. The bodies were usually interred

with the heads to the east. In almost all cases, the limbs were flexed. Two skeletons I found had evidently been buried in a sitting position. In these the lower limbs had been flexed so that the knees were drawn up nearly as high as and in front of the chin. The bodies had been placed on a layer of soil; above this was a layer of sand, and above the sand a layer of ashes. Very few pieces of charcoal were observed, and it is fair to suppose from this that cremation had not been practiced here. Aside from this there were no bones found that showed any evidence of the action of the fire. In the northern half of the mound I discovered what had formerly been posts or timbers placed on end. These were very much decayed; upon close examination they proved to be of black walnut, *Juglans nigra*, which is common in this locality. They did not occupy a perpendicular position, but had been placed about 12 feet apart at an angle of perhaps 60 degrees to the north. I examined carefully around these for anything that might have been placed there, but nothing was found. I very much regret that inclement weather and other unavoidable circumstances prevented any further investigation of the mound at that time. At some time in the near future I hope to resume the work of a more thorough and minute examination of the mound and its contents.

## ANCIENT MOUNDS AND EARTH-WORKS IN FLOYD AND CERRO GORDO COUNTIES, IOWA.

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By CLEMENT L. WEBSTER, *Charles City, Iowa.*

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Floyd and Cerro Gordo Counties, in the northern central portion of Iowa, are among the most fertile portions of the State. The region is watered mainly by the Shellrock and Cedar Rivers and their tributaries. The surface of the country is a gently undulating prairie with only narrow belts of timber along the streams and a few isolated groves or "patches of timber" adjacent to them.

The west side of the valley of the Shellrock and Lime Creek sometimes rises to a height of from 70 to 123 feet above the water in the stream, thus affording a beautiful and extensive view of the surrounding country. The soil of the entire region is a rich deep black loam, mostly of drift deposit, easily cultivated, and remarkably well suited to the production of the cereals. When first settled by the white man much less timber occupied the surface than now.

In early times this region, especially the Shellrock and Cedar valleys, was the seat of populous settlements of the red men; but not so (except in the Cedar valley), of the mound-builders, the remains of which are mostly their burial mounds and earth-works.

On the south bank of Lime Creek, at Hackberry, Cerro Gordo County, a small mound is located. This mound occupies a position on the edge of a bluff, which at this place rises abruptly to a height of 70 feet above the water in the stream, and commands a beautiful and extensive view of the region to the north, northwest, and east. By the caving away of portions of this bluff about two-thirds of this mound has been destroyed; but, judging from the portion which still remains, it must have been, originally, about 15 feet in diameter, and from  $1\frac{1}{2}$  to 2 feet in height, circular at the base, and with a gently rounded top. Excavations revealed a horizontal layer of broken pottery, the fragments almost always lying with the concave side upward. The surface of the pottery had been ornamented by rude impressions, and had been broken before being placed in the mound. This pottery occupied a position slightly below the natural surface of the ground around the mound. Associated with the pottery were numerous flint arrow-points (finished and unfinished), of various designs. In the extreme



southeast portion of the mound, and occupying a position a few inches above the layer of broken pottery, were several plates from the lower portion of the carapace of a turtle. It is possible that these plates may have gained this position long subsequent to the formation of the mound. No human bones, or other relics than those mentioned, were found.

About the center of the southeast quarter of section 5, township 95, range 17 north, and half a mile west from Flood Creek, in the western part of Floyd County, a peculiar mound is located. The topography of the country immediately adjoining this creek, in this region, is rather low and level, but not usually wet. This mound is situated on the margin of a belt of timber, bordering a low, wet depression of the general surface of the land. It was about 16 feet in diameter, and 1 foot high at the center, with a circular basilar outline and flat top, except a rounded ridge 8 or 10 inches high and 1 foot wide at the base, which occupied the outer edge of the surface area. All round the base was a trench, about 10 inches deep and 1 foot wide, from which earth had no doubt been taken to form the ridge, and, in part, the mound itself. The surface of the mound was densely covered by poplars (*Populus tremuloides*), wild plum (*Prunus americana*), and hazel brush (*Corylus americana*).

Mr. Merton T. Webster and the writer together made a partial exploration of this mound by extending an excavation part of the way through it, 2 feet wide and  $1\frac{1}{2}$  feet in depth, with the following result: First there was a layer of decomposed plant remains and earth, and then a layer of charcoal, then a bed of ashes, and afterwards a layer of soil. Below this layer of soil was another bed of charcoal and ashes, occupying the same position relative to each other as those above. This bed of ashes rested directly upon the natural surface of the ground, which did not show any particular evidence of strong heat.

This description may be illustrated by the following cut, Fig. 1:

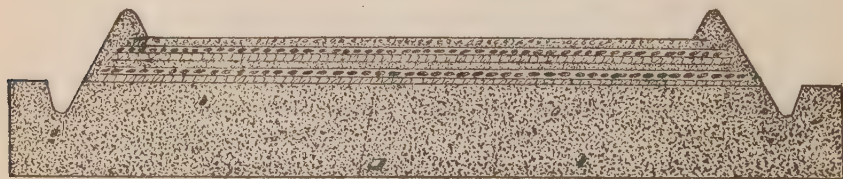


FIG. 1.—Section of ancient mound near Flood Creek, Floyd County, Iowa.

A careful examination of the charcoal, which was mostly in large pieces and finely preserved, convinced us that the fuel had been largely poplar wood. No burned bones or remains of artificial objects were found.

In the eastern part of Floyd County, near Charles City, a large and very interesting group of ancient mounds occur, most of which have been explored by the writer.

All these mounds, thirty-one in number, are located, with one excep-

tion\*, two miles northwest from Charles City, near the center of section 26†, township 96, range 16.

These mounds occur (except the three isolated ones) in a nearly straight line, running about 20 degrees west of north, on the summit of a low, broad ridge.

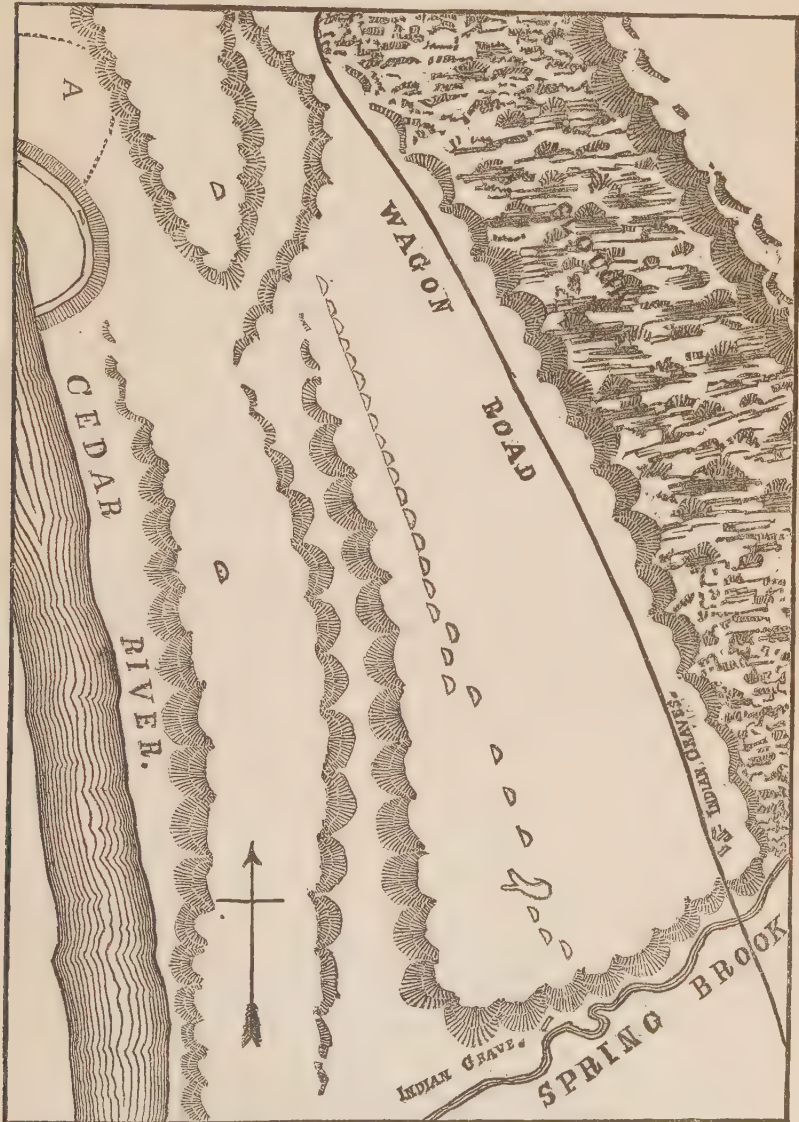


FIG. 2.—Map, showing location of Mounds.

By referring to the accompanying map it will be seen that a spring

\*This "exceptional" mound is located near the center of the southwest quarter of section 23. Section 23 joins sections 26 on the north.

† Nearly all this land is now owned by Mr. John Sringer,

brook flows past the south end of this line of mounds, and the Cedar River about half a mile to the west; while a quarter of a mile to the east is located a slough, and a longitudinal depression occurs at the base of the ridge on the west.

These mounds are in reality situated in the valley of the Cedar River, the true valley side being from half to three-fourths of a mile to the east.

This entire ridge was originally covered with a heavy growth of oaks, poplars, etc.; but most of it has long since been cleared away in the opening up of the land for cultivation.

Mound No. 1 (counting from the south end of the line), 63 feet in length, and 48 feet in width, and 3 feet in height. This appears to have been a natural elevation to which dirt has been brought and so completed the mound. This was partially explored, but nothing found. Seventy-five feet to the west from No. 1 is a circular mound 21 feet in diameter and  $1\frac{1}{2}$  feet in height. Unexplored.

Fifteen feet northwest from the last is another circular unexplored mound, 20 feet in width and 2 feet in height.

Ten feet from No. 3 is a large curved mound 163 feet in length (following the outer basal curvature), and varying from 20 to 25 feet in width and from  $2\frac{1}{2}$  to 3 feet in height. This mound tapers, and decreases in height toward the northwest, where, at the extremity, it has a height of  $1\frac{1}{2}$  feet and a width of 8 feet.

Not far from the northwest extremity of this mound occurs a spur or extension of the main mound. This spur is 27 feet long, and quite rapidly diminishes in height and width (especially in height), until at the end it is less than 1 foot high and only 10 feet in width. This appears to have been an original mound with additions made to it by human hands. Excavations were made in this mound at different points down to the level of the ground at the base of the mound, but without finding anything.

The north part of this mound is still covered with hazel brush, while the south part has been plowed over for many years.

This mound, as well as mound No. 1, seems not to have been raised for sepulchral purposes, as nearly all others of the group have been.

No. 5, a circular mound, 300 feet from No. 4,  $1\frac{1}{2}$  feet in height, 21 feet in diameter, and surface occupied by hazel brush. Unexplored.

No. 6, a mound 200 feet from the base of No. 5, circular,  $1\frac{1}{2}$  feet in height, and 21 feet in diameter. This has been degraded by the plow. Unexplored.

Between Nos. 5 and 6 there is another mound; but as there is some uncertainty regarding its origin, it is not represented on the map.

No. 7, a mound about the same in all respects as No. 6. Unexplored, degraded by the plow, and 100 feet or more from No. 6.

No. 8, a circular mound, 45 feet in diameter, 3 feet in height, and 50 feet distant from No. 7. Degraded and unexplored.

No. 9, a mound 10 feet distant from No. 8, is about 30 feet in diameter,



and  $2\frac{1}{2}$  feet in height. An exploration of this mound was made by an excavation in the center, 8 feet square, and extending down to the level at the base. From 20 inches below the surface and downward fragments of pottery were found. Lying on the natural surface of the ground was found a closely packed bundle of human arm and leg bones, lying due east and west. On the east end of these bones reposed a crushed and somewhat separated cranium, some portions of which were very thick, and the teeth large and strong. The bones and skull were those of a young adult person. Two feet to the northeast from the first bundle of bones was another similar bundle, lying directed a few degrees south of east. On the east end of this bundle lay a portion of a crushed skull. The skull and bones were somewhat charred by fire, which appears to have been done after being placed in the mound. A few feet to the southeast from the last bundle of bones, was found another similar closely packed bundle, lying directed about 13 degrees south of east. No skull was found with this bundle. A few feet to the northwest from the first bundle of bones was found another like bundle, lying due east and west; no skull was present. Scattered through the mound were a few small pieces of charcoal, hard-burned clay, and pieces of limestone showing the action of fire. Some years ago an excavation was made in the center of this mound, and a skull, together with one or two bundles of bones, was taken out. All the bones in this mound showed more or less evidence of calcination. With one exception, all the remains had been elsewhere cremated before being placed in this mound. Formerly an oak tree, 12 inches in diameter, occupied the surface of the center of this mound, only the stump now remaining.

No. 10, a circular mound, 36 feet in diameter and 3 feet in height, and 12 feet from No. 9. Degraded by the plow. An examination of this mound was made, but without finding anything.

No. 11, a mound 4 feet from No. 10, circular, 45 feet in diameter and  $2\frac{1}{4}$  feet in height. Degraded. An excavation 8 feet square and  $2\frac{1}{4}$  feet in depth was made in the center of this mound. Ten inches below the surface and slightly east of the center a piece of broken pottery and a few small fragments of charcoal alone were found. No evidence of fire was observed save the charcoal, which appears to have been brought in.

No. 12 is similar to No. 11, but slightly smaller, and 12 feet distant from it. A partial exploration of this mound was made, and numerous pieces of hard-burned clay were found scattered through it, all of which had been brought in. Ten inches below the surface of the mound a portion of a calcined femur was found. No trace of fire was noticed in the mound.

No. 13, a mound 15 feet from No. 12, circular, 45 feet in diameter and 2 feet high. Degraded and unexplored.

No. 14, a mound 16 feet from No. 13, circular, 51 feet wide and  $1\frac{1}{2}$  feet high. In the center of the mound and 10 inches below the surface, a



peculiar, imperfect skull, apparently that of a dog, was found, facing the southwest. Near this skull, and 7 inches below, were found quite closely associated five bundles of leg and arm bones similar to those found in other mounds of this series already described. In three cases a skull (crushed) had been placed on the west end of the bundles of bones, and in one instance a skull had been placed between two of these bundles. Underneath the west end of the north bundle was one-half of a lower jaw still retaining the teeth. The skull between the bundles had been placed on its right side, with mouth wide open, facing the northwest; scattered in the soil near it were numbers of its teeth, indicating that they had dropped out before being covered with earth. All the bundles of bones lay directed in an east, northeast, or southeast direction, none of them outside of the radius of the rising sun at some period of the year. In all but two instances the bones occupied a horizontal position; but in two cases they sloped upward in an easterly direction at an angle of several degrees. Seven inches below the dog skull, numerous pieces of ribs and other small bones were found, which had been thrown in promiscuously. All the skulls were rather thick, jaws and teeth large and strong. Some of the bones were those of very old individuals, while the majority were those of young adult persons. Associated with the human remains, and scattered through the mound, were numerous pieces of burned clay and charcoal which had been brought in. This charcoal was of oak of the same species as now grows in the region. Six inches below the surface of the mound two large slabs of water-worn (Devonian) limestone were found. These were obtained from the Cedar River, near by.

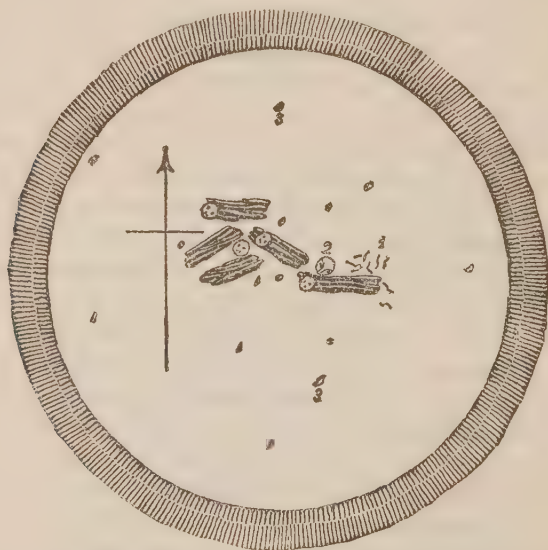


FIG. 3.—Diagram of mound No. 14. Human bones and crania. (1) Scattered fragments of rib and other small bones; (2) skull of a dog 10 inches below the surface of the mound; (3) scattered fragments of charcoal and burned clay.

The human remains had all been cremated before being placed in the mound.

The accompanying diagram (Fig. 3) will illustrate this description, as well as show the general method of interment practiced here by these ancient people.

No. 15, a mound 10 feet from No. 14, circular, 30 feet in diameter and  $1\frac{3}{4}$  feet in height. A partial exploration of this mound failed to show any indications of fire or to yield relics of any kind.

No. 16, 16 feet from No. 15, is another mound of the same character. A partial exploration of this mound revealed the presence of human leg and arm bones, 17 inches below the surface of the mound, apparently thrown in promiscuously. No trace of fire or other relics than those mentioned were found.

No. 17, a mound 3 feet from No. 16, circular,  $1\frac{1}{2}$  feet in height, and 25 feet in diameter. An oak stump 8 or 10 inches in diameter still occupied a position on the edge of this mound. Degraded and unexplored.

No. 18, a mound 20 feet from No. 17, circular, 42 feet in diameter and  $2\frac{1}{2}$  feet in height. A trench 2 feet wide and  $2\frac{1}{2}$  feet deep was made through the center of this mound from east to west, but no trace of fire or relics of any kind was found. The material of the mound was homogeneous throughout. Degraded by cultivation.

No. 19, a mound 20 feet distant from No. 18, circular, 42 feet in diameter and  $2\frac{1}{2}$  feet in height. Occupying the surface of the mound was some hazel brush, and growing on the edge was a burr-oak tree 1 foot in diameter. Near the center of the mound three large oaks had recently been grubbed up; on the stump of one was counted sixty-three annual rings. In the center of this mound an excavation 8 feet square and  $2\frac{1}{2}$  feet deep was made. Lying at length, on a level with the ground around the mound, a skeleton of an adult person was found. This skeleton lay with the head 11 degrees south of east. The body had been placed on its back, head lying on its left side, mouth open about 1 inch, left shoulder drawn up and chin resting on the clavicle, and arms at the side. The cranium was large and well formed, the jaws and teeth strong and rather large, and judging from the worn condition of the crowns of the teeth, it was that of a person somewhat advanced in years. This skeleton indicated a person over 6 feet in height. As this skeleton, together with others, was stolen soon after being exhumed, it has made it impossible to give cranial measurements here as was desired. All the bones were in a poor state of preservation. No trace of fire was observed in the mound, or relics of any description found with the bones. The earth around and for  $1\frac{1}{2}$  feet above the body had been tamped very hard.

No. 20, 21 feet from No. 19, was another mound of the same form and dimensions, and covered with a growth of hazel brush, the young oaks and poplars which but a few years ago occupied it having been cut down and removed. An exploration of this mound was made with the

following result: In the center of the mound, and 26 inches below the surface, was found three bundles of leg and arm bones, five skulls in a crushed condition, and what appeared to be two pelvis bones much decayed. In the center of this assemblage of bones was a small earthen vase or urn, set upright. Associated with and distributed in the earth above the bones were numerous pieces of charcoal, burned clay, and one or two pieces of broken pottery. The bundles of bones, with one exception, all lay in an easterly and westerly direction, while the skulls and other bones were placed here without apparent order. Most of the crania were those of young adult individuals, one of them a babe with milk teeth. Some of them however were those of very old persons, the crowns of the teeth (the teeth in all the skulls were very large) all having been worn down to and sometimes deeply into the dentine. The urn, which was of the rudest form the writer has ever seen from any mound, was nearly perfect. The bones, which were all in a poor state of preservation, were more or less calcined, some before and some after having been placed in the mound. The charcoal (one piece found was 21 inches in length and 4 inches in diameter) was of oak, and of the same species as now abundantly occupies the region and the surface of some of the mounds. The soil above and around the bones had been packed very hard.

No. 21, a circular mound, about 30 feet in diameter and 2 feet in height, and 25 feet distant from No. 20. The surface of this mound was covered by small hazel brush, and until recently by a growth of young oaks and poplars. An exploration revealed a circular, oval mound of red burned clay, 1 foot in thickness at the center and about 10 feet in diameter, 1 foot below the surface of the rest of the mound. Near the center of the mound, and underneath the burned clay, were three bundles of bones, similar to those found in other mounds of this series. Two of the bundles lay directed 11 degrees east of south; the third bundle lay directed due northwest and southeast. On the north end of the two first bundles of bones reposed a crushed skull, and on the southeast end of the third bundle was also a crushed cranium. These bones were all very much charred by fire. Associated with these bundles of bones were large quantities of other human bones, almost entirely consumed by burning. In the black soil above the burned clay a few small pieces of oak charcoal were found. Neither charcoal nor ashes, bones nor other relics, were found in the burned clay. The following section (Fig. 2) will illustrate the above description:

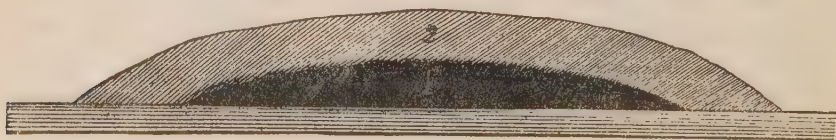


FIG. 4.—Diagram of mound No. 21. (1) Burned clay; (2) black homogeneous drift soil.



This mound appears to have been used not only as a burial mound, but as a cremation mound as well. It is known that the human remains found in the majority of the mounds of this group had been elsewhere cremated before being placed in the mounds.

No. 22, a mound of the same dimensions as the last, and 30 feet distant from it. Surface occupied by a few hazel brush and young oaks. Near the center, and 2 feet below the surface of the mound, a bundle of bones was found, together with a portion of a skull; all of which were in a much decayed condition. The bundle of bones lay due northeast and southwest. Distributed through the mound were pieces of oak charcoal and burned clay which had been brought in. There was no evidence that fire was used at this burial here. The soil around and for some inches above the bones had been beaten hard.

No. 23, 25 feet from No. 22, was a circular flattened mound, 30 feet in diameter and 1 foot high. The surface was occupied by hazel brush and a few small and medium-sized oak trees. A partial exploration of this mound was made, but no relics were found or evidence of fire observed.

No. 24, a mound, 25 feet from No. 23, circular, 45 feet in diameter and  $1\frac{1}{2}$  feet in height. Surface occupied by the same class of vegetation as the last. Three feet south of the center of the mound came upon a bundle of bones lying due east and west. Lying one on the east end and one on the west end of these bones, were two skulls. The skull occupying a position on the east end, lay on its left side facing south by southwest. Skull large, of moderate thickness, forehead low and sloping abruptly backward; teeth large and strong, and with crowns of molars and premolars worn smooth, indicating an old individual. As this skull soon crumbled in pieces on exposure to the atmosphere, definite measurements were not taken. The second skull was in a crushed condition, although a partial reconstruction of its parts was possible. Through the back part of the skull (left parietal bone) were three circular holes arranged in a line (the smaller one in the center), 5, 8, and 11 millimeters in diameter respectively. Whether these perforations were made by human hands or by the agency of some insect or its boring larva, after the burial of the bones and their softening by decay, we are unable to state. The latter supposition, however, seems to us the most probable.

No. 25, a circular mound, 45 feet wide, 3 feet high, and 20 feet distant from No. 24. Surface occupied by the same, but more dense, arboreal vegetation and undergrowth as occupies the surface of many of the other mounds. An exploration of this mound revealed nothing save a few scattered fragments of charcoal and burned clay, which had been brought in from some other locality. The material of the mound had been tramped hard.

No. 26, a mound about 53 feet distant from the last, circular, 33 feet in diameter, and 3 feet in height. Surface occupied by a few brush and the stumps of three oaks, one showing forty-eight and another sixty-one annual rings. Nothing was found in this mound except a few small pieces of charcoal of oak wood.



No. 27, a mound 5 feet from No. 26, and of the same form but somewhat smaller. Surface occupied by hazel brush. Unexplored.

No. 28, a mound 40 feet from the last, circular, 1 foot in height, and 24 feet in diameter. Surface partially occupied by small hazel brush and the stumps of a few small trees. Unexplored.

About one-third of a mile to the northwest from this line of mounds an isolated circular mound occurs. It is located on the brow of a somewhat higher and much narrower ridge, and about 40 rods from an abandoned portion of the channel of the Cedar, marked 1 on the map. This mound, we were informed by Mr. Capron, the present owner of the land, was originally about  $1\frac{1}{2}$  feet in height and 20 feet in diameter, but as it had been industriously plowed over for more than thirty-five years, its greatest height when examined by the writer was only about 6 inches.

A thorough exploration of this mound was made and with the following result: One foot below the surface of the mound, and 6 inches below the natural surface of the ground around the mound, was found a large quantity of broken pottery, charcoal, two sinkers, one rude arrow point, and a few flint chippings. All these relics showed evidence of having been burned after having been placed in the mound. One foot below the pottery, portions of a human skeleton were found. The bones (which appeared not to have been placed in a bundle) were too few and too badly decayed to allow of any definite knowledge as to the original placing of the body. A portion of the pottery found here presents a combination of net or basket markings and of separate cord markings. The regularity of the impressions upon the subglobular bodies indicates almost unbroken contact with the interior surface of the woven vessel. The rims have been ornamented by separately impressing coarse twisted cords. The rims of two of the vessels were ornamented exactly like the "Ancient British Vase" figured on page 399 of the Third Annual Report of the Bureau of Ethnology, except that the three upper and the three lower parallel lines are wanting.

Some of the vessels were smooth; all of a very moderate thickness, of a yellowish-red color, and made of pounded granite of drift origin, fine gravel, and clay. Portions of six vessels were found, and all, with one exception, having the rim variously molded and artistically decorated by the impressions of coarse twisted cords. One of the largest vessels, which was less fractured than the rest, and which admitted of a partial reconstruction of its parts, had an aperture diameter of  $20\frac{1}{2}$  centimeters, and a diameter of the large and abruptly flaring portion near the base of 31, and a height of 16 centimeters.

The neck of this vessel was sharply constricted. With one or two exceptions, all the other vessels were of the same general form but somewhat smaller.\*

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\*In a future paper we desire to give a more detailed description, accompanied by cuts, of the pottery found in these mounds, together with that of the pottery (now in the writer's possession) showing the impressions of textile fabrics, from ancient mounds in other parts of Iowa.

Some years ago Mr. Capron made an excavation in this mound and took out numerous small pieces of pottery, and one sinker larger and finer than either of those obtained by the writer.

About 6 feet to the northeast from the mound was a saucer-shaped depression 10 feet in diameter and  $1\frac{1}{2}$  feet in depth, from which dirt had been taken in the construction of the mound. It is stated by Mr. Capron that this excavation was originally much larger.

On a much lower and level space (marked A on the map) on the bank of the now abandoned channel of the river, and about 40 rods to the northwest from the mound, considerable quantities of broken pottery some of it differing greatly in decoration from any found in the mounds, has been plowed up. Considerable numbers of arrow points, together with lance points, drills, hammers, flint chippings, etc., have also been found.

It seems quite probable that this was the site of a village of these ancient people who erected the mounds.

About half a mile to the northeast from the above described mound another isolated circular mound occurs. This is located upon the extremity of the brow of a rather high and abruptly truncate ridge, which here approaches to within a few rods of the Cedar. From this point a fine view of a considerable portion of the valley may be gained. This mound, which was opened by parties from Charles City some years ago, was said to have been circular, 20 feet in diameter, and 2 feet in height.

But little information as to the result of the exploration of this mound has been obtained by the writer, save that a considerable quantity of fabric and cord marked pottery, much of it similar to that obtained from the mound on the Capron farm, was found, and that it had been subjected to the action of fire after having been placed in the mound. Several fine specimens of this pottery were sometime afterward presented to the writer by one of the party making the exploration. The larger fabric-marked specimen is of peculiar interest from the fact that in the manufacturing of the vessel the hand was used in pressing the plastic clay into shape,\* the interior of the vessel (that portion of it known) showing deep depressions or indentations made by pressure of the hand or fingers, this giving both the interior and exterior of the vessel an uneven surface.

This vessel appears to have been formed by placing the material in some subelastic mold (perhaps of willow) and pressing into form by the hand; but prior to which the mold had been lined with some coarse woven fabric, for, perhaps, the purpose (1) of facilitating the removal of the vessel from the mold, and (2) for the purpose of ornamentation. Near this mound was found (by Mr. Burt Harwood, one of the explorers of the mound) and presented to the writer numerous arrow points, a fish-spear (according to Abbot), knife, and a fine plumb-bob.

The point of special interest regarding the arrow heads is their (in

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\*In all other observed examples some smooth instrument was used for this purpose.

some cases extreme) rudeness of form. The knife, which is the most beautiful specimen of its kind that we have ever seen, is of milky quartz,  $7\frac{3}{4}$  centimeters in length, about 3 centimeters wide at the middle, and tapers to a point at either end.

The fish spear has a length of  $5\frac{1}{2}$  centimeters and width at the base of 2 centimeters; this spear point tapers gradually to the front, the forward half very thick and heavy, the breadth and thickness being about equal.

The plumb-bob is a beautiful symmetrical specimen, ovate in form, with a length of  $5\frac{1}{4}$  centimeters and diameter of  $5\frac{1}{4}$  centimeters. Running longitudinally around this specimen is a rather profound groove.

The three last named implements, knife, spear, and plumb, are, so far as known to me, of very rare occurrence in Iowa.

On the second ridge, west (which is slightly lower) from the line of mounds, and directly opposite mound No. 14, is another isolated mound. This mound is 42 feet long from north to south, and 30 feet wide and 1 foot high at the center. Formerly a fair-sized oak tree occupied the surface in the center of this mound. Many years' working of the plow has reduced the height to a considerable degree.

About 3 feet from the base of the northeast part of the mound was a saucer-shaped depression (originally larger and deeper) about 22 feet in diameter and 1 foot deep. Along the entire east side at the base was a depression somewhat shallower than the first one. From these depressions dirt had been taken for the construction of the mound.

Near the northeast part of the mound, and 2 feet below the surface of the mound and 1 foot below the natural surface of the ground around the mound, was found part of a calcined skull and several leg and arm bones. These bones had the appearance of having been placed here in a loose, careless manner, most of them lying directed north and south. Five feet to the south of the remains of the first body were the remains of a second body. This body was represented by a somewhat larger number of calcined leg and arm bones than the first one. The condition of the few well-preserved teeth found with these bones would indicate that they belonged to a person somewhat past middle life. The long bones, with one exception, all lay directed north and south.

Both bodies found here had been cremated at some other locality before being placed in the mound. From near the surface of the mound was obtained a few pieces of charcoal, flint chippings, and a small piece of pottery.

The bones in this mound, as well as the bones in many of the other mounds examined, had been considerably gnawed, and some of them destroyed, by the pouched gopher (*Geomys bursarius*). These burial mounds being usually located upon the highest and driest portion of a region offer special inducements for these troublesome rodents to appropriate them for their domiciles, which they often have done.

The charcoal found in this mound and in the mound on Mr. Capron's



farm as well was of a very fine-grained compact wood, differing widely from the oak.

Judging from the great difference (in many respects) in the mode of burial, the state of preservation of the bones, etc., it seems not improbable that they are the remains of a different tribe of the mound-builders from those who erected the line of mounds, and that the interments were made at a period considerably prior to those interments in the line.

The material of all the mounds, except the charcoal and burned clay mentioned, is a black, homogeneous drift soil, such as everywhere occupies the surface of the region. No "dugholes," ditches, or excavations of any kind (with the two exceptions noted) were observed near or adjacent to the mounds, from which earth might have been taken for their construction. The diameter of the mounds and their distance apart has been ascertained by pacing.\*

One-third of a mile to the south of the line of mounds, and at a lower level, are situated several circular mounds (now nearly obliterated by the cultivation of the soil) similar to those already described, none of which have been explored.

At Floyd, 4 miles farther up the Cedar from these mounds, there are several other ancient mounds which in general form and appearance approach those already described.

About 8 miles to the northeast from Charles City, on the southwest part of the northwest quarter of section 36, township 96, range 15, Floyd County, an ancient earth-work or fortification occurs on the east side of the Little Cedar River.† The topography of the region in the immediate vicinity of this stream is broken and possessed of considerable beauty of natural scenery. The valley of this stream is from one-fourth to one-half a mile in width, and its sides rise to a height of from 50 to 300 feet above the stream.

This fortification, as will be observed by reference to the accompanying map, is located about 150 feet distant from the bank of the abandoned channel of the Little Cedar River, and about the same distance from a ravine, which is located near the southeast extremity of the fortification and which is tributary to the Little Cedar. The bottom of this ravine and the abandoned channel of the Little Cedar, is from 18 to 20 feet lower than the base of the fortification. This fortification is located in the valley of the Little Cedar, the east valley side being one-fourth of a mile from it and, as before stated, rises many feet above it. The earth-work itself is 124 feet in length, 16 feet in width at the base, and  $2\frac{3}{4}$  feet in height. The top is gently oval, sides gradually sloping to the

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\* Thanks are here due Mr. Seringer, who, although most of the area occupied by the mounds was also possessed by fine growing crops, willingly allowed an exploration of the mounds to be made.

† This stream is little more than a large creek, although receiving the appellation of "river."



base, and ends truncate. This earth-work runs about 17 degrees west of north, and is composed of the ordinary drift soil of the region.

No "dug-holes," or other excavations, were observed, from which earth might have been taken for the construction of the fortification.

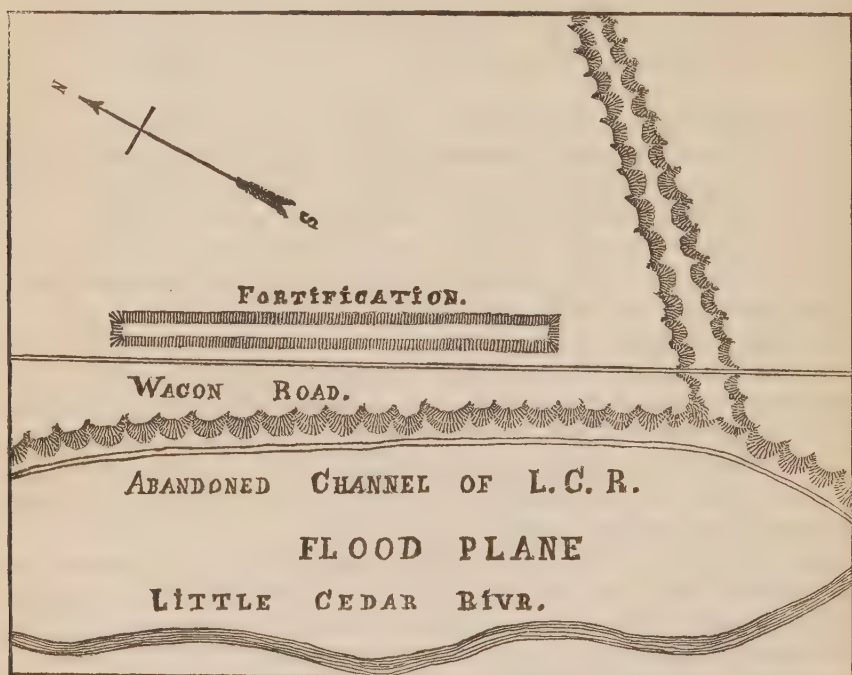


FIG. 5.—Map showing location of ancient fortification.

Several excavations had been made in different parts of this earth-work by various parties, but no relics were discovered. Flint arrow points are not unfrequently found on the surface in this region.

So far as is at present known to me, this is the first mound-builder fortification discovered in northern Iowa. It is reported that there occur in what is known as the "big woods," on the west side of the Little Cedar, 7 miles below the above locality, three mounds. These mounds are composed of drift bowlders and soil, are about  $2\frac{1}{2}$  feet high, 2 feet wide, and from 4 to 7 feet in length.

#### POSTSCRIPT.

At the time the preceding account of ancient mounds in Floyd and Cerro Gordo Counties was prepared, a portion of the surface near the southern extremity of the line of mounds was covered by an almost impenetrable growth of brush, vines, and weeds. Here were observed what appeared to be several artificial mounds; but, under the condition stated, there was so much doubt regarding their origin that no mention

was made in the article regarding them; neither were they represented in the map accompanying the paper. A few weeks ago however we made another examination of the region. The brush, etc., had been cleared from the surface and burned, thus fully exposing the mounds. They were shown to be the work of human hands, and are represented in the accompanying diagram. No. 2 is accurately represented in the map given, and is here introduced simply to show its relations to the other mounds. No. 1 is an oblong mound, 30 feet long, 24 feet wide, and 2 feet

high. From the center it slopes rather more rapidly to the north than to the south. The distance between No. 1 and 2, at B, is between 4 and 5 feet. No. 3 is a long mound, 81 feet in length, 15 feet wide at the base, and 2 feet in height at the center. The distance between this mound and No. 2, at C, is 24 feet. At A, an excavation,  $1\frac{1}{2}$  feet in depth, had been made; this excavation was much the deepest at the base of No. 2. Here doubtless was where a portion of the material for the construction of No. 2 was obtained. The material for the other mounds was apparently scraped from the surface in the immediate vicinity.

These three mounds were apparently reared for the purpose of defense. Running north by northwest (in a line) from No. 1 are several small circular mounds from 8 to 10 feet in diameter. For what purpose these were raised, we are at present unable to state, as no exploration of them has been yet made.

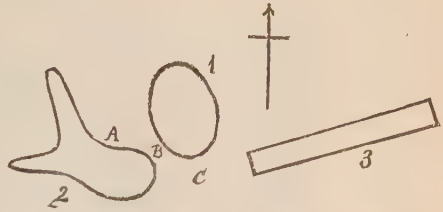


FIG. 6. Supplementary to Fig. 2. (p. 577).

## INDIAN GRAVES IN FLOYD AND CHICKASAW COUNTIES, IOWA.

By CLEMENT L. WEBSTER, *Charles City, Iowa.*

Our Indians, like the wild buffalo, are fast disappearing before the advance of civilization. Only a few generations hence and the last vestige of this once noble race will have disappeared, and nothing be left to mark their occupancy of this broad and beautiful land of ours save the few graves of their dead which dot our hills and valley sides. And even these silent records of a fast vanishing race are rapidly disappearing with the march of time. So it seems fitting and well that whatever of interest they may possess be recorded now.

On a low but dry piece of ground, in what was known as "Carman's Woods," near the confluence of Beaver Dam Brook\* with the Shellrock River, one-half mile north from Rockford, in Floyd County, a peculiar Indian grave is located.

This grave is 7 feet long,  $2\frac{1}{2}$  feet wide,  $1\frac{1}{4}$  feet in height, and 3 feet in depth.

Mr. Merton T. Webster and the writer together made an exploration of this grave, but without finding human remains or relics of any kind. The grave had been excavated in the soil down to the underlying limestone strata. Running lengthwise through the center of the grave, from bottom to top, was a row of limestone slabs from 2 to 3 inches in thickness set up edgewise.

For the first foot the grave had been filled in with small fragments and blocks of limestone; the rest of it was then filled by laying in, obliquely, slabs of limestone on each side of the central row, one edge resting in the outer portion of the grave and the other against the central row of stones. The surface slabs were so large and heavy as to require the entire strength of one man to remove them.

The following section (Fig. 7) will illustrate this description.

Two miles northwest from Charles City, in Floyd County, are located a group of four Indian graves† This group of graves is situated on

\* This is now called "Whisky Creek" by some.

† The exact location of this group and the isolated one above described are indicated on the map (Fig. 2) which accompanies the preceding paper entitled "Ancient Mounds and Earthworks in Floyd and Cerro Gordo Counties, Iowa." (*Ante*, p. 577.)

high, dry ground, back to the north from a small creek which comes in here from the east.

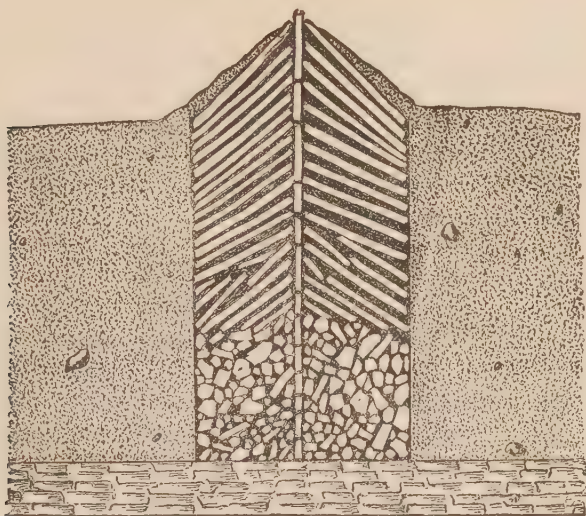


FIG. 7.—Transverse section of Indian grave near Rockford, Iowa.

These graves are apparently made like ordinary graves of the whites. With one exception they all lie directed northeast and southwest, the exceptional one lying due north and south. They all occur close together. Three of them are nearly 7 feet in length; the fourth one is that of a small child, and is only about 3½ feet long.

It is said by old settlers that these graves have been known here ever since the country was first settled, over thirty years ago, and that "they probably belong to Winnebagos."

About one-fourth of a mile to the west-southwest from the above described group an isolated grave might have been seen a few years ago. The history of the death of the one whose resting-place it was has been furnished me by some of the old pioneers of the section who were personally acquainted with the facts. The history, in brief, is this: In the winter of 1849-'50 a band of Winnebago Indians came in here from the east (?) on a hunting expedition; among the number was the son of the chief of the tribe, eighteen or twenty years of age. In chasing a bear this young Indian became over-heated, took cold, a fever setting in, and he soon died. His body was wrapped in his blanket and placed on the ground in the timber on a level space back from the creek a short distance. He was laid at length, with head to the northeast and feet to southwest. Slabs of green wood, 3 feet long, were then split out and placed over the body in an inverted V-shaped form, meeting at the top. The ends of this inclosure were then closed up by other slabs. At the head of this a post of green wood 6 inches in diameter was firmly driven into the ground, after the bark had been carefully removed. This post



extended 3 feet above ground, and on it was rudely painted with some red pigment figures resembling Xs, Ys, etc. Around this inclosure a tight log crib was made. This crib was 10 feet long, 7 feet wide, and slightly over 3 feet in height, and was made of green unpeeled logs, from 6 to 7 inches in diameter, laid up in log-house style, and so notched at the ends as to leave but little if any space between them, this being intended to keep the wolves and other wild animals from the body. Over the top of the crib were tightly fitted other logs. The skull of this Indian is now in the possession of Dr. J. W. Smith, of Charles City.

One mile below the above-described grave, in the timber on the south bank of an elbow of the Cedar River, which extends out here to the east, there might have been seen a few years since the graves of several Winnebago Indian children. The bodies had apparently been placed on the surface of the ground, and on all four sides logs 12 inches in diameter had been arranged, the space inclosed being filled in with earth, and a mound 13 inches or more in height raised over the body. These graves were situated on the bank, 10 feet above and 10 or 15 yards distant from the stream.

On the brow of the hills, which here form the east valley side of the Little Cedar River, at Bradford, in Chickasaw County, and where a beautiful view of the surrounding region is afforded, formerly existed a Winnebago burial ground. Here more than twelve Indians were buried. Their bodies were wrapped in their blankets; a quantity of provisions, their guns, and other things, supposed to be needed in the "happy hunting ground," were placed at their sides. Over the body an inclosure was formed by driving staves into the ground obliquely on each side, meeting at the top, as described in the burial north from Charles City.

As these graves were located on the prairie, no log crib was placed around this inclosure; but instead, clods of earth were arranged all around the outside, completely covering the slabs from view save a slight portion at the top. In the heavy timber on the west side of the stream at this place numerous other graves existed. Here tight log cribs, similar to the one already described, were placed around the inner inclosure. In one instance the body of the dead was put in a rude slab coffin and placed on crotched poles, 10 feet from the ground. In another instance the body of a papoose was laid in a rough slab box, and this placed in the crotches of a tree.

Whether the two last burials were those of the Winnebagoes, or those of some other tribe, I am unable to state with certainty, although the settlers living in the region at the time affirm that they were those of the Winnebagoes.

The Indians in passing up and down this stream during the summer and fall "would place wisps of June grass on the graves of their dead."

## ANCIENT MOUNDS IN JOHNSON COUNTY, IOWA.

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By CLEMENT L. WEBSTER, *Charles City, Iowa.*

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Johnson County occupies a position in the southeastern portion of the State. Its topography is peculiarly that of loess regions, being for the most part a very rolling and (along the streams) broken prairie country. This area is watered by the Iowa River and its tributaries. The Iowa is a beautiful meandering stream. Entering the county near its northwest corner, it flows almost due east to the center of the county, where it abruptly turns and continues its course through the region in a south by southeast direction. The valley of the Iowa River and its tributaries is relatively narrow and deep, and bordered by more or less steep acclivities and flanked at frequent intervals by deep but narrow and rapidly ascending ravines.

The immediate valley of the Iowa River attains an average width of slightly over one-half of a mile, and its channel has been eroded to a depth varying from 50 to over 175 feet below the valley borders. The small tributaries have also eroded their course to a depth of from 10 to 80 feet. There are no extensive marshes or swamps.

The soil of the area is for the most part a yellow homogeneous loess, and is of quite inferior quality for farming and the production of the cereals compared with the rich black drift soil of other portions of the State to the north.

The valley of the Iowa, especially in the northern half of the county, with its heavy skirting of timber, fluted sides, and often bold escarpments of Devonian rock, is perhaps one of the most beautiful regions in the State.

This valley was once the seat of a populous settlement of the mound-builders, as is evidenced by their remains. Of these silent records of a long vanished race the most important as well as the most legible are the earthen mounds which cover the bones and dust of their dead. They crown many of the peaks and ridges of the bluffs, most of them assuming only moderate proportions while large numbers are mere swellings of the surface not readily recognized as being of artificial origin—this arising mainly from the degradation by the plow.

Along the Iowa in this county there are known to be, or have been, at least one hundred of these mounds. It would be useless labor and waste of time to attempt to locate on a map the situation of each mound in Johnson County, and a tedious and unprofitable repetition to detail minutely the examination of each separate mound.

For brevity of description they can be readily grouped in two classes according to their form, and the description of one will answer generally for all of its particular class.

The first class of mounds, and by far the largest in number, are circular at the base and have an oval or flattened top, a diameter varying from 12 to 24 feet, and a height of from  $1\frac{1}{2}$  to 3 feet. The second class of mounds are long and narrow, sometimes forming an extension to one of those of the first class. These mounds have, so far as observed, a length varying from 45 to 130 feet, with a width of from 12 to  $13\frac{1}{2}$  feet, and a height varying from  $1\frac{1}{2}$  to 2 feet.

Near Mr. Iker's, 5 miles north from Iowa City, occurs an interesting group of these ancient mounds, eighteen in number, located in a line on the summit of a high, narrow ridge, which forms the east bank of the Iowa and the west bank of Sanders Creek, and extends nearly parallel to them.

The highest point of this ridge rises about 100 feet above the bed of the Iowa River, but to a lesser height above the bed of the creek. From this ridge a beautiful and more or less extensive view of the valley is obtained. The mounds are arranged in a slightly curved line, following the crest of the ridge. The surface of the summit of the ridge has a slope of several feet from the south to mound No. 5. From mound No. 12 the surface gradually rises until within about a quarter of a mile an altitude varying from 25 to 30 feet is attained above the base of this mound.

The accompanying map will illustrate the position and relation of the mounds to one another, while the table will give their dimensions, etc.

No.	Width.	Length.	Height.	Direction.	Distance.
	<i>Feet.</i>	<i>Feet.</i>	<i>Inches.</i>		<i>Feet.</i>
1	24	.....	24	N. to No. 2	54
2	20	.....	24	N. to No. 3	45
3	18	.....	24	N. to No. 4	40
4	16	.....	27	N. to No. 5	72
5	24	.....	36	N. to No. 6	33
6	12	130	18	N. to No. 7	36
7	18	.....	24	N. to No. 8	15
8	17	.....	30	N. to No. 9	48
9	15	.....	30	N. to No. 10	30
10	15	.....	24	N. to No. 11	75
11	16	.....	30	N. to No. 12	33
12	$13\frac{1}{2}$	45	20	N. by NE. to No. 13	30
13	14	.....	36	N. by NE. to No. 14	125
14	17	.....	24	N. by NE. to No. 15	24
15	12	.....	18	N. by NE. to No. 16	24
16	24	.....	24	N. by NE. to No. 17	170
17	19	.....	36	N. by NE. to No. 18	90
18	24	.....	36		

Most of the mounds have been partially, and a few thoroughly, explored by Mr. M. W. Davis, of Iowa City, who has taken much interest in their study and the securing of their relics, of which he has now quite a large and valuable collection obtained from this county.

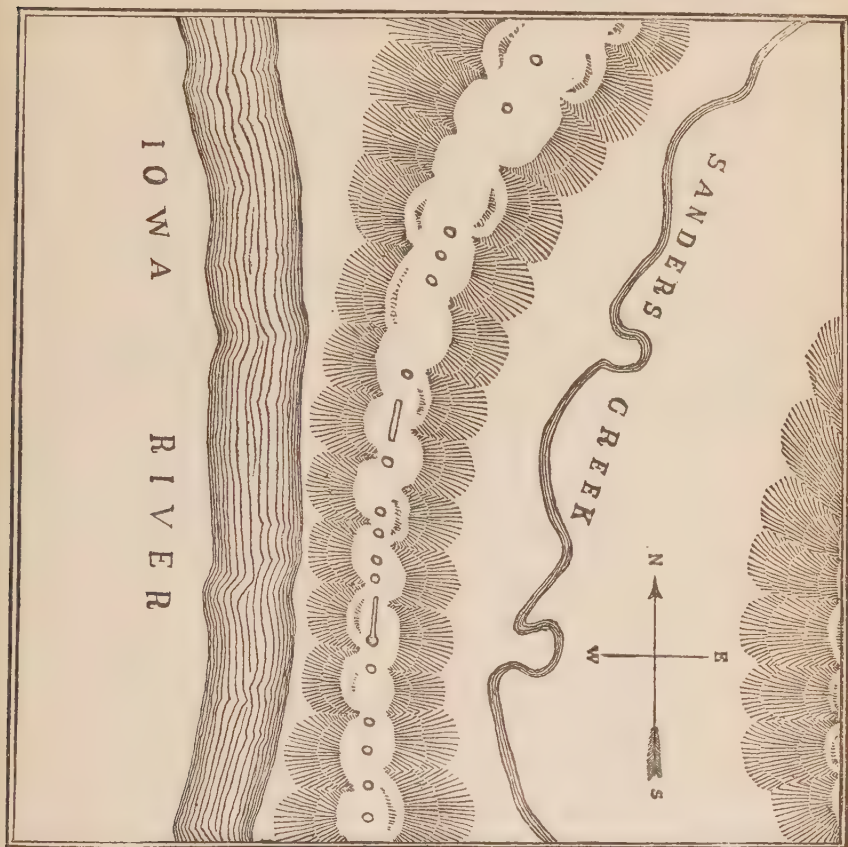


FIG. 8.—Map showing position of Mounds.

To Mr. Davis I am indebted for most of the notes on the exploration of these mounds.

In mound No. 1 (counting from the south) a skeleton of an adult individual, in a sitting posture, was unearthed; near this was also found a small peculiar shaped vase of burned clay, made apparently to represent some horned ruminant. These relics were found at or slightly below the natural surface of the ground around the mound. In mound No. 2 was found the skeleton of a child, "apparently about seven years old." The bones in this mound, as well as the bones in mound No. 1, were in a poor state of preservation.

It is reported by Mr. Davis that in nearly all other mounds examined by him fragments of human bones were found, and in nearly all mounds a layer of charcoal and ashes occupied a horizon a few inches above the



human remains. He also reports the finding of several burned drift boulderettes in some of the mounds.

Mound No. 11 was partially explored by the writer by making a trench 2 feet wide and  $2\frac{1}{2}$  feet deep through it from north to south. Nothing was found save an arrow point, a few flint chippings, and several boulderettes of drift origin, probably placed here by human hands. No evidence of fire was noticed.

Mound No. 6 is of peculiar form, and for what purpose it was originally constructed is difficult to conjecture. The large expansion at the south end is circular in basal outline, with a diameter of 40 feet and height of  $1\frac{1}{2}$  feet. Extending north from this portion is a long, oval, or slightly flattened mound. The entire length of this mound, as indicated in the table, is 130 feet. Some feet north from the large expansion the writer made a trench 2 feet wide across this mound, but without finding any trace of fire or relics of any kind.

Mound No. 12 is another peculiar form, and appears to have been raised for the same purpose as mound No. 6, whatever that may have been. This is unexplored.

The material of all the mounds (except the ashes and charcoal mentioned) is a yellow homogeneous loess, with a dark humus-stained layer at the top, such as everywhere occupies the surface of the country. No "dug-holes" or excavations of any kind were observed near the mounds from which their material might have been taken. The ridge and mounds here are covered by a heavy growth of young oaks, hickories, poplars, etc.

On the opposite side of the valley, and slightly below this group, is another group of five circular mounds. These occupy a position on the brow of a ridge which commands a beautiful view of the valley and country to the east.

As these mounds are in the main identical in form and structure with the circular ones of the first group, a delineation of them here is unnecessary.

These mounds have been partially explored and the finding of human bones in them reported. Near the mouth of Turkey Creek, 2 miles north from the first group of mounds described, an isolated circular mound occurs. This mound is situated on the brow of a perpendicular cliff of Devonian limestone which rises to a height of 100 feet (by estimate) above the water of the Iowa, and constitutes one of the highest and most sightly localities of the vicinity. This mound is somewhat higher than any of those previously described. It has been partially explored, but with what result is unknown to the writer.

Near the flouring mill, half a mile north from Iowa City, there occurs, on the top of a high but rather narrow ridge, two series or lines of circular mounds. This point commands a fine view of the surrounding country. The mounds are usually low and from 20 to 21 feet in diameter and 30 feet distant from one another. They occupy the center of

the ridge, and in doing so are sometimes deflected from a true north and south line. There are from fourteen to sixteen of these mounds, a large number of them having become almost obliterated in the cultivation of the soil.

A portion of these mounds was explored many years ago, but with what result we have been unable to learn.

About one-half or three-quarters of a mile to the northwest from the mill, a row of from fourteen to sixteen long and circular mounds existed, but most of them have now disappeared before the plow. The form and dimensions of these mounds were about the same as those already described at other localities.

As these mounds were long since explored, it is unknown to us what relics, if any, were obtained.

At various other points along the Iowa River, in Johnson County, circular and linear mounds occur. At no locality have "dug-holes," trenches, or other excavations been observed near the mounds which would indicate where the material was obtained for their construction.

Although stone relics are rarely found in the mounds, yet field relics, such as stone axes (sometimes very large), drill-arrow- and lance-points, etc., are common.

It is a matter of regret that a complete record of the results obtained in the exploration of these interesting mounds has not been kept.

## ANCIENT MOUNDS IN IOWA AND WISCONSIN.

By CLEMENT L. WEBSTER, *Charles City, Iowa.*

Along the shores of the "Father of Waters" in Iowa and Wisconsin there once existed large numbers of that deeply interesting but little known race, the mound-builders. How long the shores of this mighty river continued to be the home of portions of this race, can not even be conjectured. But the valleys and bluffs of this cliff-bound river are dotted with the monuments of these departed people.

Large numbers of these ancient mounds have been explored and the record given to the world of science, while perhaps a still larger number have been explored and the records and relics lost.

In this paper is chronicled the result of explorations in a few of these ancient mounds. These explorations were made by Dr. W. T. Knapp, now of Charles City, Iowa, and to whom I am indebted for most of the following facts :

In the town and vicinity of Guttenberg, which is located on the level flood-plain of the valley of the Mississippi, on the west or Iowa side of the river, are located large numbers of small circular and long mounds, most of which were reared apparently by the present Indian race.

Large numbers of these mounds have been opened by those incited merely by curiosity, and many valuable facts and relics obtained only to be so on irreparably lost.

Nearly, if not quite all, these mounds contained, in greater or less abundance, implements, ornaments, etc., of copper, silver, and stone, as well as human remains.

Some of the mounds here are 124 feet in length, and contain great quantities of human bones. Numbers of these burials have been made in recent time and have been witnessed (so claimed) by white men now living. Most of the burials are those of Indians.

One mound at Guttenberg opened by Dr. Knapp was circular, 16 feet in diameter at the base, and 3 to 4 feet in height. In the center, 2 feet below the surface of the ground at the base of the mound, was discovered a human skeleton, the bones being in a fairly well preserved condition. On each side of the head was found a large circular silver ornament, 2 inches in diameter, which, from their position, would indi-

cate that they had been worn suspended from the ears. With the body was also found a number of flint arrow points. There was no evidence that fire had been employed at this burial. The material of the mound was rather soft, moist soil. There seems to be no doubt but that this burial was that of an Indian.

About  $4\frac{1}{2}$  miles west from Guttenberg, on the steep side of a deep ravine, through which Miners Creek courses its way, was a burial mound. This mound was located about 60 feet above the bed of the creek, and was some 7 feet wide and 10 feet long. Excavations in this mound revealed the presence of a well-preserved human skeleton, together with stone arrow points, pestle, pipe, and other implements of stone. The pipe (which the writer has personally examined) was a beautiful and finely wrought specimen, made from red pipe-stone. The soil from which this mound was constructed was soft—considerably softer than the earth surrounding it. This was doubtless an Indian burial.

On the brow of a bold perpendicular bluff, which rises some 250 feet above Buck Creek, near where it empties into the Mississippi and between 5 and 6 miles southeast from Garnaville, Iowa, an earthen mound occurs. This mound had a circular basal outline and oval top; was  $3\frac{1}{2}$  feet in height and nearly 24 feet in diameter. In the center and  $2\frac{1}{2}$  feet below the surface of the soil surrounding it a finely preserved human skeleton was discovered. The body had been placed at length, with the head to the north and the feet to the south. The temple of this individual had been crushed in as if by a heavy blow from some blunt instrument, and which had doubtless been the cause of death. No implements or ornaments were reported found with this body.

The material from which this mound had been made was not packed, as is frequently the case with many other ancient mounds in different portions of the State. The summit of this bluff was covered with timber, and one large "hard maple" tree, about 2 feet in diameter, occupied the surface of the mound.

Near Buena Vista, in Clinton County, Iowa, between 3 and 4 miles west from the Mississippi, there occurs on the summit of a high hill a very interesting ancient mound. On exploring it a rude box, constructed out of large stone slabs, was discovered, and in it the remains of a human skeleton. The body had been placed at length, with the head to the north and the feet to the south. In the box with the body a large quantity of stone implements, as arrow points, axes, etc., were found.

Near Cassville, Wis., a sub-circular mound, 40 feet in diameter and 5 feet in height, is situated. This mound is located on the flood-plain (above the reach of high water) of the Mississippi, and less than 100 feet back from the margin of the stream. A partial exploration of this mound was made, and human bones discovered, some 2 feet below the base. With the human remains was found a considerable quantity of stone implements, among the most interesting of which were



a number of hoes or spades, two of the finest of which are now in the author's collection. These hoes were made from chert, probably derived from the Silurian rocks of the region, which in places contain great quantities of nodules of this material. The largest hoe in the writer's possession has been rather roughly chipped out; is 4 inches in length and 2 inches in width; the lateral margins nearly straight or slightly curved, the anterior end rather broadly rounded, and the posterior truncate. The smaller specimen is cordate in outline,  $2\frac{3}{4}$  inches in length,  $2\frac{1}{4}$  inches in greatest width, and abruptly truncate posteriorly. Growing on the surface near the center of the mound was an oak tree  $2\frac{1}{2}$  feet in diameter.

Near the last mound was another circular mound, 15 feet in diameter and between 3 and 4 feet in height. Close to the center of the mound, and  $2\frac{1}{2}$  feet below its base, a single human skeleton was unearthed. The body had been placed on its back with the head to the north. The knees were drawn up to the breast, the elbows bent, and the hands brought to the sides of the face. With the body were found large numbers of copper ornaments, which, from their position, showed that they had been used as leg and arm ornaments. Judging from the structure and delicacy of the bones, this body was that of a woman. Fire had apparently not been used at this burial.

On the Mississippi, 6 miles north from Glen Haven, Wisconsin, are situated four or five ancient burial mounds. These mounds are composed of sand and are from 18 to 20 feet in height and from 20 to 30 feet in diameter.

Owing to the fact that the owner of the land on which two of these mounds are located was unwilling that these works should be disturbed, the internal structure and contents of them is unknown. One of this group of mounds, partially explored by Dr. Knapp, contained large quantities of human bones.

Near Glen Haven is an interesting Indian grave. This grave is located on a flat ledge of rock on the bank of the Mississippi, 50 feet above the stream and at the base of the bluffs which form the valley side, and which rise from 200 to 300 feet above the water in the stream. A few feet from this grave a spring of water issues from the rocks. The body had been placed at length in a rude box made of slabs of limestone and with the head to the north and feet to the south. Over this box a small earthen mound had been raised. With the body were found (lying near the breast) large numbers of stone implements, as axes, arrow points, skinners, pestles, etc., some of them objects of much interest. One or two old pioneers of the region, who claim to have been present at the burial of this Indian, assert that it was that of the half-brother of Black Hawk. As to the truthfulness of this statement, however, we do not vouch.

The measurements of the mounds and their exact position relative to known points given in the foregoing description may be regarded as only approximate.

*Method of flint-chipping.*—Some years ago Dr. Knapp, while making a reconnaissance of "Twelve-mile Island," in the Mississippi near Guttenberg, Iowa, made the acquaintance of a roving band of the Pottawatomic Indians who were encamped for the time on this island. While among them he witnessed the process of flint arrow-point manufacturing as carried on by this band, and as the writer has not observed a description of this process in print before, a short account of it is here given.

A tree from 12 to 20 inches in diameter was selected and a large notch or cavity 6 inches in depth was made in one side of the trunk at a sufficient distance from the ground to allow of a person occupying a sitting posture on the ground to work this "instrument" with facility. The upper portion or roof of this cavity sloped obliquely downward; the farther side was perpendicular and the bottom horizontal. On the bottom of this cavity a small even slab of rock of some hard material was placed. A short distance above this rock a small hole or notch was made in the farther side of the cavity. Into this notch was inserted the "leg bone of a deer," and under this was placed, edgewise and resting on the basal rock below, the piece of stone to be wrought, this possessing the quality of conchoidal fracture. The implement was then deftly worked out by pressure of the carefully manipulated cylindrical bone.

The size of the instrument to be wrought was regulated by moving the specimen farther from or near to the outer margin of the basal rock.

This description may be further illustrated by the following cut (Fig. 9) from a rude sketch of the "instrument" made by Dr. Knapp:

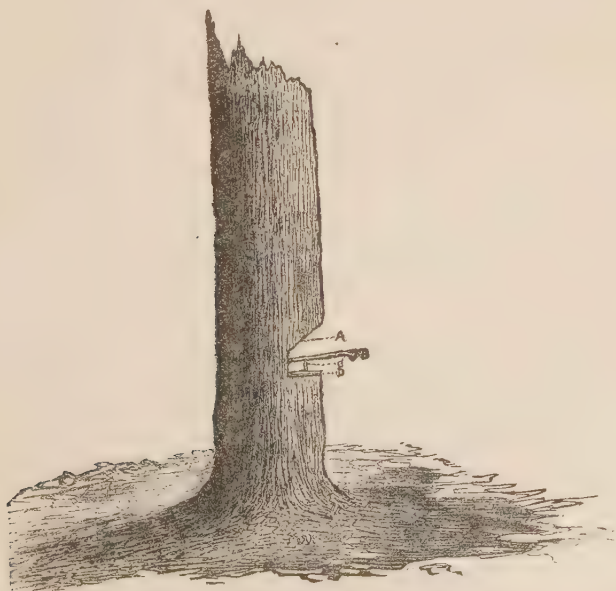


FIG. 9.—(a) Cavity cut in the tree; (b) cylindrical bone of "deer's leg;" (c) stone to be wrought; (d) basal stone.

Another method of flint arrow-point making (which we have not seen noted elsewhere) practiced by some of the existing tribes of Indians was described to the writer by Hon. S. P. Leland, of Charles City. This method was observed by Mr. Leland as he was among some of the Indian tribes of the Western Territories a few years since.

This process consisted in the application of heat and pressure. First, three stones of some hard material not easily acted upon by heat, of a rounded form, about 5 inches in diameter and 6 inches in length, were placed in the fire and heated hot. Then a fragment of stone of suitable size and quality was selected to be wrought. One of the stones was then taken from the fire and applied with pressure to the edge of the piece of stone to be worked, this causing chips or flakes to be broken from the piece. While the first stone was still hot it was replaced in the fire and a second one taken out and used as the first. This process was repeated until the work in hand was finished. By this method beautiful arrow points were wrought.

## MOUNDS OF THE WESTERN PRAIRIES.

By CLEMENT L. WEBSTER, *Charles City, Iowa.*

In travelling over the beautiful prairies of the West the attention of the traveller is struck by the beauty and number of the flowering plants which are presented to view on every hand, their bright yellow, blue, pink, and other varied colors and hues being in happy contrast to the rich green of the prairie grass among which they mingle. The different portions of this emerald expanse, as high and low, wet and dry, support, to a greater or less extent, their own peculiar flora. The fineness, coarseness, richness, or sterility of the soil of its different parts have often a marked effect upon the distribution of many of its species.

Regions much trodden over by the cattle, on the large Western ranges, present beautiful fields of gold, in the latter portion of the season, by the blooming of myriads of plants of the order *Compositæ*, many of which are represented by the genera *Vernonia*, etc.

Another characteristic which attracts the attention of the traveller who for the first time passes over this beautiful region is the scarcity or absence of all arboreal vegetation, the only timber of this region being confined to the margins of some of the streams which meander through it and the small isolated groves which occur upon it.

But a widely prevalent feature, which attracts perhaps no less interest but more speculation, even among many of those who have long inhabited these prairies, is the great number of isolated or grouped mounds which are seen over the surface, and which are often denominated by the inhabitants as Indian mounds. These mounds are generally circular and have an oval or flattened top with a diameter at the base of from 4 to 20 feet, and commonly rise to a height of from 1 to 3 feet.

Although the marginal outline of these mounds is usually circular, still at times some of them are oblong or have a gently flowing contour. These mounds are either isolated from 5 rods to 1 mile from one another, or are closely and irregularly grouped, or grouped into rude circles, semi-circles, or even straight lines. In some instances, as many as sixteen of these mounds have been counted in an area containing about 2 acres.

The location of these mounds is almost exclusively in the prairie regions and may be found on high and dry or low and rather moist



land. In Iowa and southern Minnesota, where these mounds have been most studied by me, they may be seen for many miles over the level prairies of these regions.

During the summer and early autumn they are usually clothed with a very luxuriant and rank growth of perennial plants, most prominent among which are observed *Calamagrestis canadensis*, *Vernonia pasciculata*, etc. These rise to a height of from 4 to 13 feet above the surface of the ground at the base of the mound, and thus constitute a very conspicuous feature of the surface.

Although the external appearance of these mounds is analogous to that of some of the Indian mounds of Iowa and other States, still they may be distinguished from those of the mound-builders by their relative position and the region occupied, as well as by their greater irregularity of contour.

For more than twenty-five years I have resided in the prairie regions of the West, and have thus been afforded a fine opportunity to study the origin and development of these "singular" mounds. By far the greater number of them owe their origin to the pouched gopher (*Sacomys bursarius*), that year by year has made additions to them by dirt brought forth in the extension of their under-ground channels until they finally assume the proportions now seen. Upon the death of the animal, or for some other cause, these mounds and channels are finally abandoned and the mounds left to be taken possession of by the indigenous plants of the region, which are always, under such circumstances, of much ranker growth than is usual under other conditions.

Others of these mounds are developed by the American badger (*Taxidea americana*) and the prairie wolf (*Canis latrans*). The mounds formed by the badger and wolf may be distinguished from those of the pouched gopher by their large and partially filled burrows. The burrows of the badger are always located upon the highest and driest portions of the region, and those of the prairie wolf usually upon the border of "runs" or general surface drainage depressions of the country. These mounds have sometimes been described and published as works of the "mound-builders."

## THE TWANA, CHEMAKUM, AND KLALLAM INDIANS, OF WASHINGTON TERRITORY.

By Rev. MYRON EELLS.

### NAMES AND SITUATIONS OF THESE TRIBES.

*Twanas.*—The name of the Twanas is spelled Too-au-hooch, in their treaty. The Klallams pronounce it Tu-an'-hu. The Twanas say Tu-ád-hu. The difference between the Klallam and the Twana language here exemplified is often observed—the Klallam being the more nasal. These various pronunciations have been shortened into Twana, now used in all governmental reports. It is said to mean a portage, and to be derived from the portage between the head of Hood's Canal and the main waters of the Sound, where the Indian, by carrying his canoe 3 miles, avoids rowing around a peninsula 50 miles long.

These Indians originally occupied both sides of Hood's Canal, and were divided into three bands, the Du-hle-lips, Skokomish, and Kolsids. The Du-hle lips lived at the head of the canal, where a small stream empties into it, now called Du-lay-lip. Fifteen miles below them were the Skokomish, who lived around the mouth of the river of that name, now their reservation. This word is pronounced Skâ-kâ-bîsh by the Twanas and Ska-ka-mîsh by the Klallams. The Americans have changed it to Skokomish, and thus they universally spell the name of the river, reservation, and post-office. Dr. Gibbs, in vol. 1, "Contributions to North American Ethnology," gives this as the name of the tribe, but it was originally the name of only one band. Yet even now, because of its being the name of the reservation and river, these Indians are known fully as well by the name Skokomish to the whites on the Sound as by the name Twana. Skokomish means the "River People;" kâ, signifying fresh water, is doubled to denote one form of the plural, probably because of the size of the river, which is by far the largest that empties into the canal. The termination *ish* is very common for the Indian names of tribes and streams on the Sound. I incline to the opinion that it comes from what is called the old original form of plural in the Twana language—the suffix *obish*.

There are two ways of forming the plural—one by reduplication, the other by adding this termination; both seem to be combined in this word. The prefix letter *o* is, I have often noticed, in other words.

In conversation I have heard them pronounce the names of the tribes Makah and Haidah, S'ma-kah and S'haidah, and yet when I have asked how they pronounce the names of those tribes they would reply Ma-kah and Haidah. Many times, too, in collecting common words they have been pronounced as beginning with an *s*, and in a second pronunciation the letter would be dropped. After careful inquiry I have generally concluded to drop the *s* as the more correct. When first used by the whites the whole word was written S'Kokomish.

Thirty miles below this band were the Kol-sids, as pronounced by themselves (or Kol-sins by the Klallams), who lived around the bay of that name and the mouth of the Dos-wail-opsh River. Their name is now variously spelled by the whites: Colcins, Colcene, Colseed, and Quil-cene. These three bands were not always at peace, but sometimes waged petty war with each other. For twenty years, however, they have mostly been collected on the same reservation, have been on good terms with one another, and have intermarried, so that the band distinctions are rapidly becoming obsolete. Yet, when the older Du-hle-lips have the reservation for fishing they are apt to go to their old waters, and the same is true of the Kol-sids.

The dialects of the different bands formerly varied a little: Thus the word for *go* in Du-hle-lip was *bī-se-dab*, but in Sko-ko-mish *bī-hé-dab*. At the present time, not finding it practicable in collecting the vocabulary to separate the dialects, I have gathered most of the words from older school-boys who have been brought up on the reservation and familiar with the different dialects which are now rapidly merging into one.

At present most of these Indians live on the reservation. A few families live between it and Seabeck, 30 miles north of the reservation; about thirty persons make Seabeck their home, where the men earn their money mainly by working in the saw-mill and the women by washing.

Although the Skw-aksin tribe by treaty and language belong to the Nisqually Indians, yet about thirty of that tribe, since the selection of the Skokomish reservation, have moved to it and become incorporated with the Twanas. They have done so because their own people are scattered and nearly extinct as a tribe and because of the nearness of the reservation to their old haunts and numerous marriages between them and the Twanas. They use their own language for the most part, but the majority understand the Twana, and the Twanas understand them.

*Chémakums*.—In the treaty their name is written Chemakum; George Gibbs writes it Tsemakun; J. G. Swan spells it Chem-a-kum, which represents the way in which both the Indians and whites of this region pronounce it. The whites call a prairie by this name. Its origin or meaning I can not learn. These people call themselves Á-hwa-ki-lu. They occupied the land from the mouth of Hood's Canal to Port Discovery Bay. According to their tradition and that of the Kwilleuts, they originally came from the latter tribe, who live on the Pacific coast

south of Cape Flattery, 125 miles distant, and from whom they are now separated by the Clallams and Makahs. In regard to this, J. G. Swan says that the Kwilleuts have a tradition that a long time ago there was a very high and sudden tide, which took four days to ebb, after which a portion of the tribe made their way to the vicinity of Port Townsend, and are known as Chemakums. The latter tribe have a similar tradition. The Chemakum numerals seem to corroborate this legend. They are said to have been originally a war-like tribe, not very numerous, but strong and brave. They had a village at the head of Port Townsend Bay called Tséts-i-bûs, which was a kind of a capital for nearly all the tribes on the Sound, where they occasionally collected. George Gibbs, in 1852, states that their number is ninety, but they are now virtually extinct, there being only ten left who are not legally married to white men or into other tribes. Of these ten there is only one complete family, four in number. With the exception of two or three very old persons, they now mainly speak the Klallam language. They say that their diminution was caused by small-pox, but probably war had something to do with it, as Gibbs says they have been engaged in wars with the Makah, Klallam, Twana, Snokomish, and Duwamish Indians, by whom their power has been broken.

*Klallams.*—In the treaty this name is spelled S'Klallam, but I am inclined to think that the "s" is the same as that in S'kokomish. Other tribes now call them Klallam, from which the whites have derived this word; but it evidently originated from their own name for themselves, Nu-sklaim, meaning a strong people, for they were formerly a strong tribe. Their territory at one time extended from Port Discovery Bay to the Hoko River, on the northern coast of Washington Territory. The treaty expected them to go to the reservation, and the Government was to furnish the means for this purpose. This was never done, and they have never been moved, except that some have occasionally been taken there for a limited period as punishment for crime. At present many of them have moved further up the Sound to obtain work. Their villages are now as follows:

(1) Opposite Seabeck, where for a long time about thirty have lived, but of late all but about a dozen have moved to Port Gamble. Their main dependence for money is from their work at the saw-mill.

(2) Opposite Port Gamble, across the bay, 20 miles north of Seabeck, are about one hundred who earn their money principally at the saw-mills there. This village is enlarging and has a small Catholic church.

(3) Around Port Ludlow, 6 miles north of the last place, are nine who depend on the saw-mill there for their living.

(4) In and around Port Townsend, 13 miles north of Port Ludlow, are about twenty. More would live there, as from the size of the place they could easily find work, but the facilities for obtaining whisky are so great the agent has forbidden them to come there.

(5) Around Port Discovery, 14 miles west of the last place, are nearly



forty Indians who gain their livelihood mainly from the saw-mills at that place.

(6) Fifteen miles northwest of them is Sequim, where there are forty more. Most of these are old or infirm people who get their food chiefly from the water, but make some money by canoeing for the whites to Port Discovery and Port Townsend.

(7) Six miles north of Sequim is Jamestown, near Dungeness, in and near which are about one hundred. Six years ago these Indians were so worthless (being almost constantly drunk) that the surrounding whites were considering the subject of petitioning the agent to remove them. Hearing of this the leading ones, as they did not wish to be taken from the home of their fathers, determined to reform. Gathering together their money they bought 210 acres of land, divided it among themselves according to the amount of money furnished by each, and have been steadily improving it. They have also improved in morals until they are now the most civilized and prosperous band of the whole tribe. Their village fronts the water and the houses are on one street, which is straight and presents quite a neat appearance. This is the home of the head chief of the tribe, and they have a school, church, and jail. They gain their living by agriculture and by working and canoeing for the neighboring farmers.

(8) Eighteen miles farther west is Port Angeles, where there are about thirty-five Indians nominally resident. Many years ago the United States custom-house was at this place, work abundant, and the Indian village lively; but the custom-house was afterwards removed to Port Townsend, the whites left, and employment became scarce. Many of them live at other places a good share of the year, and when at home they make some money by canoeing for the few whites to Dungeness, Port Discovery, Port Townsend, and Victoria.

(9) Eight miles west of them is Elkwa, Elwhah, or Elwah, a village of seventy-five. These once formed a very strong band of the tribe, being almost independent of the others, but they are not so now. They live largely on fish, but canoe considerably to Victoria and Dungeness for the few whites near them, and some of them spend considerable time at other places working, and go to the Makah waters for seals. Three men here and one at Port Angeles have taken homesteads a mile or two back from the salt water, and are the only members of the tribe who live so far away from it.

(10) Thirty miles farther west is Pisht, with thirty Indians.

(11) Ten miles still farther west are Klallam Bay and Hoko, with forty more. These live more on fish and after the old Indian style than the rest of the tribe. They, however, canoe and seal some and gather salmon and halibut for a cannery recently established there. I can learn of only two dialects spoken by this tribe; the Elkwas and those west of them being said to speak as if with thicker tongues than those east of them, and so to pronounce some words somewhat differently.

The vocabulary which I have obtained is from the eastern members of the tribe, but I do not understand that there is enough difference to make it advisable to do anything with the other.

Besides the Indians just mentioned there are about seventy-five more in various places who properly belong to the tribe. Many of these are now on the northern side of the Straits of Fuca, in British Columbia.

The three tribes here spoken of are so nearly alike in their manners and customs that I have thought it best to describe them together, simply noticing the points in which they differ. To have described them separately would have involved much useless repetition.

The Klallams believe that they were all, except the Chemakums, created where they now are; and also that nearly all other tribes and nations were created each one where it now lives. They have no reliable knowledge of their own history earlier than the recollections of the oldest Indian.

In obtaining their names for various articles I have often found that persons of eighteen or even twenty-five years of age do not know the names for stone arrow-heads, axes, chisels, anchors, rain stones, and the like, which went out of use soon after the whites came. This shows how quickly the past is forgotten with them. The following stories were mostly written for me by a Twana school-boy, as they were told him by his father:

*“Queen North and the Colcine Indians.*—While the Colcine Indians were at peace in their habitations, a girl went out and looked into a house and saw many of their enemies (in her mind) getting ready to go into every house of the Colcines. She returned and told her master's family, but they would not believe her. The same day a boy went to get some water; when he looked into the water he saw some shadows, which were smiling, and these were the Queen North Indians; so he went home in haste to tell his parents, but they would not believe him. The girl took one of her master's sons and hid in the woods. Hence these Indians were not afraid, and so were all killed, except the girl, the little boy, and one man, for the Queen North Indians went into every house and slew the Colcines. One man took his small babe and ran away. His enemies pursued him, and when he saw they were about to overtake him he laid down his child and began to swim the bay. The Queen North Indians knew that they could not swim after the man, so they took his child and cut it in pieces. When the girl came back she found her master dead, because he would not believe her.”

*“The Victoria Indians and two families.*—Two families were travelling together, and at night they lodged. While they were there some one shot from the woods, and when they looked they saw some Indians. One family went off as fast as they could, but the other had left their child near a log. The Victoria Indians took him, but his father got ready and fired at them, and they restored the child. My father thought

that if they should shoot at their enemies they would think them brave and be afraid. The child that was taken captive is still living, and the daughter of the brave man is also alive."

"*Queen North again.*—After the battle the Colcines went out to search for their enemies, whom at last they found. Then they made a great shelf over their own beds. Their enemies came and were placed under the shelf, and one of them took a wife from the daughters of the Colcines. After a long time they laid themselves down on their beds, and the Colcines cut the ropes which held up the shelf. It fell down on the heads of the Queen North Indians, and none of them escaped. Once the Colcines bored some holes in the bottom of their canoes when their enemies came to see them. As they went home the Colcines started to take them across the bay. When they were in the middle of the bay they took out the sticks, the water came into the canoes and filled them. The Queen North Indians were drowned, but the Colcines were saved, because their neighbors went to them and helped them. So the Colcines prevailed over their enemies, and there was peace."

"*Story of another family.*—There was a man with his wife and children. One woman, who was very fair, was walking with a babe and some boys and girls. This was the daughter of the sick man, but when she came home she found some other Indians slaying the family, and her father was killed. These took hold of her; one wanted her, another wanted her, and all wanted her, and so they killed her, and none had her. The man's wife dug deep in the ground, put one of her daughters there and covered her over; she did also the same for herself, and another person climbed a tree, and none saw her, so three were left alive. The man was sick, and yet they showed him no mercy."

"*A fight with a grizzly bear.*—A long time ago a man came to the canal to marry a wife. He found one, and gave some things to her father. The woman loved the man, but her father did not like his son-in-law, but threw away the things which the man gave him, hence the man went home. After awhile this woman and some others went to gather berries. My mother's mother was among them. The woman had a companion, and the two went away from their comrades where they saw the bear, but they did not fear it, they simply talked about it, and made fun. The bear went off, but after a time they saw it again, when they talked just as at first. The bear went around to the woman who wished to marry the man and suddenly jumped at her. The other woman went to help her, but soon received some wounds, so that she left and went to tell her other comrades, while the woman kept fighting with the bear. Poor woman! She called aloud to her companions to help her, but they ran home to tell the news. She was soon killed, but her friends told her parents, and that night very many people gathered together with spears, arrows, and knives to fight the bear. When they reached the place they told the woman's parents to stand on a fallen tree, so that they would be safe. Then they surrounded the bear and



had a great fight. They shot the bear and wounded her on each side, but after a while she ran away and they ran after her. But after a time they had no more arrows or spears, with the exception of two or three young men, who still followed her. When they reached a muddy place the bear stood on her hind legs and danced. The young men became frightened and ran back. When they looked at the dead woman they found very many wounds in her."

NOTE.—Thus far I have given the stories just as they were written for me by the school-boy. The last one I presume is true in the main, as I have heard it from several parties.

The Twanas relate that a long time ago they were camped in a scattered condition on Hood's Canal, nearly 10 miles south of Seabeck. The Klallams came and killed those farthest north, taking some girls captives. Those farthest south were afraid, and some wished to flee, but others said no. The Clallams, however, did not come to them, but returned. Four or five captives were taken.

*History by the whites.\**—George Gibbs says the first visit by the whites of which we have any knowledge was in 1789, by Captain Hendrick, of the *Washington*, or in 1790 by Lieutenant Quimper, Spanish, in the *Princess Royal*. They came as far as Dungeness. Two other vessels came a year or a year and a half later, but they did not go above Port Discovery. In 1792 came Vancouver, who gives the first account extant of these Indians. He visited the three tribes, Skokomish (Twana), Tsemakung, and Klallams, and was probably the first who ascended Hood's Canal. After that, until within about thirty years, the greater part of their intercourse was with the Hudson Bay Company, who had no fort in their land, though it had one to the north at Victoria and another to the east at Nisqually. During these thirty years the Americans have supplanted the British traders. We have erected saw-mills, stores, and towns, and have cultivated farms in the midst of these Indians.

In 1855-'56 the Indians on the eastern part of the sound were engaged in war with the whites, but neither of these tribes, as tribes, engaged in it, and they have never been at war with us. A few of the Twanas crossed the sound and joined the other Indians in that war, but white men lived among the Twanas during the whole war in safety. January 26, 1855, a treaty was made with the three tribes at Point No Point, which was ratified by the Senate March 8, 1859, and proclaimed by the President on the 29th of the following April.

The Indians chose a place near the mouth of the Skokomish River in the Twana land for their reservation. By the terms of the treaty a blacksmith, carpenter, farmer, physician, and school-teacher, with annuity goods, were to be furnished them for twenty years. An agent or sub-agent has also been furnished to them. The first agents were appointed under the political plan, which lasted until 1869, when the mil-

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\*Vol. I, Contribution North American Ethnology,



itary took charge for about a year, and then another political agent was appointed. In 1871, under General Grant's religious or peace policy, the nomination of the agent was assigned to the American Missionary Association, since which time there has been no change.

The census for 1878, the last full one taken, gives their population as follows:

Twanas: Men 68, women 84, children 78, unknown 20; total, 250.

Klallams: Men 149, women 171, children 147, unknown 80; total, 597.

Chemakums: Men 5, women 4, children 4; total, 13.

Total of three tribes, 800.

Gibbs, in the volume of North American Ethnology already referred to, gives as the census for 1852, or thereabouts, Twanas 290, Chemakums 90, and Klallams 926; total, 1,306. I have some reasons for thinking his estimate too low.

Mr. H. C. Hale, whose father was for a time superintendent of Indian affairs in this Territory, has informed me that he at one time, many years ago, soon after the treaty was made, issued rations to twenty-eight hundred Indians at this agency; but probably there were more present than belonged to the three tribes, as other Indians would be likely to come at such a time. Again, I get no estimate from any old settler that there were less than two and a half times as many twenty years ago as now, and some estimate them at five times as many then as now.

A census of the Indians is very difficult to obtain, and this may be one reason why Gibbs placed them so low. In the winter of 1877-78 the agent traveled from Skokomish to Elkwa and obtained the names of four hundred and fifteen Klallams between Seabeek and Hoko, and estimated that there were one hundred more of them on the British Columbia side. Two months later I was at Dungeness to observe a potlatch, where every village of the tribe was well represented, and obtained the names of about forty-five more, and most of these lived between Elkwa and Hoko, in the region where the agent had not traveled. The Elkwa Indians, although living not more than 40 miles from the most distant of these tribes, had failed to remember many of them.

I see no reason why the country might not have supported a large number of Indians, for while they get quite a share of their living from the waters of the sound now, the whites are exporting to California and other places salmon, halibut, and clams from their waters.

Mr. Finlayson, of the Hudson Bay Company, made a count of the Klallams in 1845 and ascertained their number to be 1,760.

Gibbs\* (1852-1855) gives 926 Klallams, 90 Chemakums, and 290 Twanas. In 1870 a census was taken by the Indian Department which gives the names of 194 men, Klallams and Chemakums, 233 women, 97 boys, 81 girls, 15 infants, unknown 11; total, 631. Twenty-seven of these were Chemakums, 291 Twanas.

These Indians have undoubtedly decreased greatly since their first

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\*Cont. to North American Ethnology, vol. I, p. 183.

intercourse with the whites. The Klallams and Chemakums have decreased more rapidly than the Twanas. An accurate census of the Twanas in 1875 gave 259 in all the families which I am now able accurately to trace. In 1879 there were in the same families 239 persons.

Until within a few years intemperance has been one of the greatest foes to the lives of these Indians. The Klallam head chief has said that five hundred Indians have been killed by the saloons of Dungeness within twenty years. This is probably an exaggeration, but not a very wide one. The diseases consequent upon licentiousness and consumption have caused the death of many. At a very early day, too, small-pox undoubtedly worked great destruction, and whooping cough and measles have made havoc among the children. All of these diseases except consumption were introduced by the whites.

As the subject of the increase and decrease of the Indians has been quite widely discussed of late, I submit the following suggestions: On the first contact with the whites they decrease, but if the tribes are large and keep together somewhat compactly, and there is comparatively little intercourse with the whites, except on the outer edge, and wholesome efforts are made to civilize them, they do not diminish rapidly, and when somewhat civilized they begin to increase, as Drs. Riggs and Williamson, of Dakota, state. But where the tribes are small and the intercourse with worthless whites is considerable their decrease is rapid, and sometimes a tribe will become extinct before it has time to rally. This has been the case with the Chemakums.

*Progress.*—This has not been uniform in all localities and with all classes, those on the reservation and near the whites having progressed the most, while in the most favored places the older Indians have not changed much. As a whole, these tribes may now be called more than half civilized. The Twanas have progressed more than the Klallams, chiefly because they have had more instruction and help from the Government; yet, many of the latter tribe have made as strong individual efforts as their more fortunate brethren to improve their condition.

In regard to food, the estimate of the agent for 1878 is that 75 per cent. is obtained by Indian labor in civilized pursuits and 25 by hunting, fishing, and by gathering roots and berries. The Twanas generally have tables and some have table-cloths.

I was lately present at one feast where tables, white table-cloths, chairs, dishes, and civilized food had entirely superseded the old style equipments and provisions. On the 1st of July, 1878, they prepared a long table out-doors, with seats and a stove near by to warm tea, coffee, etc., with a full supply of dishes and food, much the same as the whites on this coast would have done at a feast.

Many have abandoned the old way of smoking the salmon, their native food, and have adopted the American style of salting it. Potatoes, flour,

and sugar are almost as indispensable to them as to the whites, while they also purchase pork and beef, rice, beans, coffee, tea, butter, yeast-powders, saleratus, salt, lard, spices, sirup, dried and green apples, crackers, cherries, and pears; and raise in their gardens corn, peas, beans, onions, turnips, beets, carrots, parsnips, cabbages, and raspberries.

*Medicines.*—They are slow to use the white man's medicine (although on the reservation they are furnished free of charge), often preferring their old remedies in slight cases of illness, and in severe cases their tamanous. If a medicine cures quickly they like it; but if after a few days they are not well, they abandon it. Those who live off the reservation seldom have any treatment except in the old style.

*Houses.*—Most of the Twanas and a large number of the Klallams east of Port Angeles build their houses in the style of the whites, with floors and stoves or fire-places, and often their houses have two or three rooms. These now dislike the ground and dirt floor, the smoke and the communal room. Some of the women regularly wash their floors, but with the majority there is room for improvement in this respect. The rooms have been almost entirely changed from the old one-sided shed style of long boards to two-sided roofs of shakes or shingles. Whenever they can they buy sawed lumber, locks, and windows. Brooms, chairs, and benches are in common use. It seems still, however, somewhat difficult for many of the women to sit on chairs when sewing; they then prefer a mat on the floor. Many have some kind of civilized bedstead, but there are still a large number of the old-fashioned kind fastened to the wall all around the room. Carpets or rugs are very scarce. Mats, baskets, and ladles are in common use, and still manufactured, but are steadily yielding to American articles for similar purposes, while dishes, knives, forks, cups, lamps, and buckets are used by a large number. When they are logging they live very nearly as well as their white neighbors in the same business.

*Clothes.*—I have never seen one of these Indians dressed in the old native style, but there are some of the older ones and those more remote from the towns who wrap themselves in a blanket when at home, only putting on their civilized clothes when going abroad. This is more common among the Clallams than among the Twanas. On the Sabbath and on public occasions they appear well dressed, mostly clean, and some quite tastily robed. At such times hats, linen coats, white shirts, broadcloth coats, woolen and calico dresses and good shawls are common. The only exceptions in respect to dress reform are among the women, who have been slow to adopt shoes, and still seldom wear any head covering, except a shawl. The ornaments formerly worn in the nose have been entirely abandoned. Other ornaments, such as finger-rings, ear-pendants, bracelets, and the like, except among the aged and conservative, are mostly purchased of the whites. Tattooing is going out of practice, many of the older Indians being ashamed of the figures



on themselves. Painting of the face is not common, except at the tamamous feasts and potlatches, and sometimes when gambling. Mirrors, brushes, combs, and soap of American manufacture are commonly in use.

*Implements.*—The native articles for general use, war and the chase, fire-making, building, and agriculture are almost entirely abandoned, and those of civilized make have taken their places. In fishing they use many of the old style articles, as they see no advantage in giving them up; but when they see something that is an improvement and they can obtain it, they are not slow to do so. Native tools for leather-working and working fiber are more common than American ones, but knitting, carding wool, and sewing are entirely reformed. Paints and ropes are mostly American.

*Travelling.*—They cling to their canoes, for they are lighter and swifter than American boats.

American standards are used in measuring and valuing. Their music is mostly native, and so their art-work.\*

*Social customs.*—Most of the Twanas under forty years have been married in our style as well as theirs, but none of the Klallams, except those who are land owners, as otherwise the property would not descend to their children. Permanent marriages is becoming quite common, and polygamy is dying out. New polygamous marriages are not allowed, and there are but ten men in both tribes who have more than one wife each. Slavery is dead. Potlatches are said to be growing somewhat less frequent than formerly, some having abandoned them entirely. The custom, though, has a strong hold on the northern Klallams. The majority of the able-bodied men among the Twanas and those of the Klallams who live at Seabeck, Port Gamble, Port Discovery, and around Jamestown, and a few others are engaged in civilized labor, the Twanas being occupied as farmers, loggers, and day laborers, and the Klallams mainly in saw-mills and as day laborers. They raised in 1878 1,125 bushels of vegetables, 120 tons of hay, and 20 bushels of grain; cut 100 cords of wood; owned 72 horses and 68 cattle, and cultivated 150 acres of land—an increase over 1872 of 900 bushels of vegetables, 30 tons of hay, and 18 cattle, and a decrease of 30 bushels of grain and 28 horses. Their principal crops are hay and potatoes.

In 1878 a number of them voluntarily gave a day's work each as their contribution to the road taxes of the country. Children are cradled mainly in the old style, but the custom of flattening the head is dying out.

*Morals.*—There is progress here, but it is slow. There is very little theft among the Twanas, more among the Klallams, but not a large amount. Falsehood and profanity are common, and it is difficult to induce them to abandon either. In regard to chastity they also improve.

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\* For Gambling and Language, see *post*, pp. 647 and 652.



Murder is rare. Parental and filial love are quite strong, and the poor are generally cared for by their relations and friends.

#### SURROUNDINGS.

*Outline and size of Territory, elevation, and water systems.*—Reservation near the head of Hood's Canal on Puget Sound in Washington Territory, and at the mouth of the Skokomish River. It is nearly square, and comprises about 5,000 acres; two-thirds of it but a few feet above tide-water, the other third mountainous and several hundred feet high. The Skokomish is the only river which, coming from the north in the Olympic range of mountains, flows east on the south side of the reservation and north on the east side, when it empties into Hood's Canal. There are several sloughs running from the river to the canal across the reservation.

*Geological environment, both stratigraphical and economic.*—The stratigraphical environment has not been thoroughly studied. Both lava and granite evidently lie at the bottom; the granite I think to be the oldest. Since the granite, evidently there has been a long washing either by salt water or fresh, I do not know which, but presume it was salt, as the upland is mostly a gravel-bed. As the sea then went down, the river formed most of the soil good for cultivation.

*Economic condition.*—The soil of about two-fifths of the reservation is black rich bottom land, very excellent for cultivation when cleared of the timber which covered it. One-fifth of the land is swampy, and 1,800 acres, nearly two-fifths, is gravelly and covered with fir timber and is almost useless except as timber land.

*Climate.*—Chiefly a dry and wet season as in western Washington and Oregon, but little snow and cold weather generally during the winter, but a large amount of rain, which continues at intervals during the summer. The spring is generally backward, as the Olympic Mountains, some of which are snow-capped during the summer, are but 20 miles distant to the north. Frosts in the fall, generally not early, coming from the 1st to the 25th of October usually.\*

The following is a list of the mineral substances which are of practical value to them; they are, as far as I know, fourteen in number, besides the soil for cultivation.

I am indebted to Prof. T. Condon, of the Oregon State University, for many of these named:

Agate is used for arrow-heads; basalt for the same and for hammers; beach stones for anchors, hammers, sinkers in fishing, and for slinging and tanning stones; black mud of salt marshes for dyeing; chalcedony for arrow-heads; clay stones for pipes and rain stones; clay of a red and a clay color for paints; jasper for arrow-heads; metamorphic stones for axes and adzes; quartzite for hammers and whetstones; sedimen-

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\*Eells on Twanas, p. 61.

tary rock for hammers; slate for knives, and trap rock for hammers and tanning stones.

## PLANTS.

The following fifty varieties of native plants are of practical use, besides cultivated plants and grasses for stock :

*Alder*.—The wood is used for fire-wood and for making dishes, plates, ladles, bailers, and masks, and for the building of fish-traps and rough houses. The bark is used for medicine, strings, ropes, and dyeing.

*Barberry*.—The bark is used for medicine.

*Blackberry*.—The berry is used for food, the juice for paint, the young leaves for tea, and the roots for medicine.

*Cat-tail rush*.—The blades for making one kind of baskets and partly in making several other kind ; for mats, which are among their most useful articles, and for strings and ropes. The head was formerly used in making blankets.

*Cedar*.—This is the most useful vegetable production of their country, its woods being used for planks for houses, burial inclosures, and the like ; for canoes, oars, baby-boards, buoys, spinning-wheels, boxes, torches, arrow-shafts, rails, shingles, fish-traps, tamanous sticks, and fire-wood. The limbs for baskets and ropes ; the bark for baskets, mats, sails, baby-head covers, springs, bailers, women's skirts, and, when beaten, beds for infants, wadding to guns, napkins, head bands, blankets, and for gambling purposes ; the gum and leaves for medicine.

*Cherry*.—The bark is used for strings and medicine.

*Cottonwood*.—The wood is useful for fire-wood, the bark for medicine and strings, and the buds for medicine.

*Cranberry*.—The berry is employed for food, the juice for paint, and the young leaves for tea.

*Crab apple*.—The wood is used for wedges, hoes, and fire-wood ; the fruit for food, and the bark for medicine.

*Currant*.—The berry for food.

*Dogwood*.—The wood is manufactured into gambling disks and hollow rattles, and is used for fuel.

*Elder*.—The wood is made into arrow-heads, used as playthings ; the bark used for medicine, and the berry for food.

*Fir (red)*.—The wood is valuable for fire-wood, boards, masts, spear-handles, spits, and oars ; the bark is preferred to everything else for fire-wood, as it is often 2 or 3 inches thick and pitchy. The pitch wood is good for torches, fire-pots, and kindlings, and for the latter use it is sold to the whites. The pitch is used for fastening on arrow-heads and spear-heads, and as a cement.

*Gooseberry (two varieties)*.—The berry is used for food and the juice for paint.

*Grass*, specific name unknown, is used extensively in making and ornamenting baskets of several kinds.

*Hazel*.—The nuts used for food, the wood for rims for snow-shoes, nets, and the like, and the bark for strings.

*Hemlock*.—The wood serves for fire-wood and halibut hooks, the leaves for tea, and the branches for covers in steaming food.

*Huckleberry (black)*.—The berry is used for food and the juice for paint.

*Huckleberry (blue)*.—Same purpose.

*Huckleberry (red)*.—Same purpose.

*Ironwood*.—The wood is used for arrow-shafts, arrow and spear heads, and mat needles, and the bark for medicine.

*Indian onion*.—The bulb is eaten.

*Kelp*.—Strings and ropes are made from the root.

*Kamast*.—The root is edible.

*Laurel*.—This is used for making spoons, vessels, and fancy work, as it is easily carved; the leaves are medicinal.

*Licorice*.—The root is used for medicine.

*Maple*.—The wood is utilized for hacklers, mat-blocks, paddle oars, bobbins, and blocks for making seines, combs, fish and duck spear-heads, fish clubs, rails, and fire-wood. The leaves are used in steaming.

*Maple (small variety)*.—The wood for fire-wood.

*Moss* is used for wrapping around wood while steaming it to make bows, the whole being buried in the ground.

*Nettle*, used for making strings.

*Oregon grape, barberry (?)*.—The root and bark are valuable for medicine, the root for dyeing.

*Raspberry*.—The berries used for food and the juice for paint.

*Rose*.—The roots and leaves serve as medicine.

*Rush (round)*.—For making mats.

*Rush (small)*.—Roots for food.

*Sallal berry*.—The berry used for food, the juice for paint.

*Salmon berry*.—The berry and young shoots are eaten.

*Skunk cabbage*.—The leaves used as medicine and the roots for food.

*Spruce*.—The wood is carved and the leaves employed medicinally.

*Strawberry*.—The berry is gathered for food.

*Thimble cap*.—The berry and young shoots are good for food.

*Vine maple*.—The wood is burned for fuel.

*Willow*.—The wood is occasionally used for fire-wood and the bark for strings.

*Yew*.—Paddles, bows, and fish-clubs are made from this wood.

#### BEASTS.

Fifteen kinds of animals are useful to them, as follows:

*Bear (black)*.—The flesh is used for food, the skins for robes and quivers, and the teeth for ornaments.

*Bear (grizzly)*.—The skin is dressed for robes, but it is a scarce animal; supposed to be used by medicine men for making people sick.

*Beaver*.—The meat for food, the skins for furs, and the teeth employed in games.

*Cat (wild)*.—The flesh is eaten ; the skins are made into robes.

*Dog (common)* is of use for domestic purposes, hunting, and the like.

*Dog (wool)*.—The hair used in making blankets. The breed now extinct.

*Deer*.—This is probably the most useful wild animal known to them. The flesh used for food, skins for robes, strings, fringes, moccasins, clothes, and shot-pouches. The fawn-skins are sometimes made into buoys, used in whaling. Formerly they made shirts, which answered the purposes of shields or suits of armor, out of buckskin. Of the sinews they make thread, and of the hoofs, rattles used in religious dances. The brains employed in tanning.

*Elk*.—The flesh serves for food ; the skins for robes, shield-shirts, and when dressed, for strings and clothes ; of the horns they make chisels, wedges, and paint.

*Musk-rat*.—The skins are used for furs, and the teeth they gamble with.

*Otter*.—The flesh is eaten.

*Otter (sea)*.—The fur valuable.

*Panther*.—The skins are made into robes and clothes.

*Raccoon*.—The skin is used for furs, and the flesh for food ; the bones for dishes and ladles.

*Wolf*.—The skin is used for robes, quivers, and caps.

The intestines of several of these are used for holding oil, and the bones for various articles, such as awls, arrow and spear heads, combs, fastenings, and the like.

#### BIRDS.

There are seventeen kinds of birds, which they utilize as follows :

*Crane*.—The flesh is used for food ; the feathers for beds and pillows, and also for ornamenting the hair at festivals.

*Ducks*.—Seven varieties of these, viz : The mallard, pin-tail, scoter (?), wood-duck, teal, diver, and canvas-back, are used for food, and the feathers for the same purposes as the crane feathers.

*Eagle*.—The feathers are used for feathering arrows and in tamanous head-bands.

*Grouse*.—The flesh for food.

*Goose*.—The flesh for food.

*Gull*.—The flesh serves for food for old people occasionally, and the feathers for beds.

*Hawk*.—The feathers are worn in tamanous head-bands.

*King-fisher*.—A piece of the skin, where the tail or wing feathers enter it, was used in fishing attached to the line near the hook, as it was superstitiously supposed to attract fish.

*Loon*.—Two kinds, the light and dark, were used for food, and the feathers were made into beds.



*Woodpecker (red-headed).*—The feathers are employed for feathering arrows and in tamanous head-bands.

*Pheasant.*—The flesh is eaten.

#### FISH AND OTHER MARINE ANIMALS.

Five kinds of these are used as follows :

*Abalone.*—The shells for money and ornaments.

*Clam.*—Three kinds of clam are used for food, and the large shells as drinking dishes.

*Cod-fish.*—The flesh and eggs of two kinds are used for food.

*Crab.*—Two varieties are used for food.

*Dog-fish.*—Oil obtained from it; occasionally the flesh is eaten; the bones are used for ornaments, and a part of the skin as a substitute for sand-paper.

*Dentalia.*—The shells for money and ornaments.

*Flounder.*—Two varieties are used for food.

*Halibut, herring, and mussels.*—Also used as food.

*Olivella.*—The shells used for ornaments and sometimes money.

*Oyster.*—Food.

*Porpoise.*—Food and oil.

*Salmon.*—Five varieties, viz: Silver, dog, red, black, and hump-backed; both the eggs and flesh are used for food, and the eggs for bait.

*Seal (fur).*—Is highly esteemed.

*Seal (hair).*—Buoys used in whaling, small sacks, pouches, etc., are made from the skin; oil is made from the blubber, and the flesh is eaten.

*Shark.*—From this oil is obtained.

*Smelt and sea-eggs.*—Used as food.

*Scallop.*—The shells are used for rattles in tamanousing, and the flesh for food.

*Skate and trout.*—Food.

*Whale* furnishes food and oil, bones for war clubs, sinew for thread, and whale-bone for a part of the cod-fish hook.

*Cuttle-fish.*—Food.

#### SOCIAL CUSTOMS.

*Travels.*—These are confined chiefly to places where those reside among whom they inter-marry. A few however of each tribe have been on sailing vessels to California.

*Commerce.*—I have seen dishes made from the horn of the mountain sheep or goat, which are said to have come from the Stikine Indians of British Columbia, 600 or 800 miles to the north; baskets and pipes from the Klikitats of eastern Washington, 150 miles to the east; baskets from the Chehalis and Cowlitz Indians, 100 miles to the south; and baskets from the Quinaielt Indians, on the Pacific coast, 50 miles to the

west. The articles from these distant tribes are, however, limited in number, but there is considerable traffic among Indians who live inside these limits. The distances spoken of above are in a direct line; the way by which the articles come is much farther.

The traffic with the northern nations is by water, and therefore over a more circuitous route than the traffic with other tribes, which is by land.

#### CULTURE.

*Means of subsistence.*—Food formerly consisted solely of fish, roots, berries, and game, the spontaneous products of land and water.

The fish and marine mammals formerly used are still eaten, and are of at least nineteen kinds, namely, two varieties of cod-fish, two of flounders, five of salmon, the silver, dog, red, black, and humpbacked, and one each of dog-fish, smelt, skates, hair-seal, trout, whale, halibut, herring, porpoise, and cuttle-fish. The dog-fish is used only occasionally when other food is scarce. The salmon, halibut, herring, and smelt are dried as well as eaten fresh, the salmon being split open and the backbone being taken out. The halibut is cut into strips, and the herring and smelt are dried whole. Salmon are now also sometimes salted. Besides the flesh of the dog-fish, porpoise, seal, and whale, the oil was formerly eaten. The eggs of the cod-fish and salmon are a luxury. The porpoise, from its resemblance to pork, is called Indian pork.

Ten kinds of shell-fish are used for food, four of them being different varieties of clams, two of crabs, and one each of oysters, mussels, sea eggs, and scallops, the latter two being found only in the Klallam waters. Clams alone are dried. In drying them the Indians first build a large fire, in which they heat a number of stones, and when the fire has nearly burned down, they remove the coals, pour on the clams, perhaps bushels of them, and cover the whole with several thicknesses of mats. They are thus steamed until they are cooked and opened, when they are taken from the shell, spitted on slender sticks 2 or 3 feet long, and put over fires in their houses to dry.

Fish eggs are dried by being placed on small wooden frames, a foot or two square, and placed over the fire. Salmon was formerly their staff of life, and their chief business in the summer was to dry it for winter. There are some kinds of fish in their waters all the year round, though some varieties they do not eat unless food is scarce.

*Roots and branches.*—The kamass was formerly the most prized, but as it does not grow in their land, having been imported from quite a distance, they seldom use it now.

The root of the skunk cabbage, steamed, the Indian onion, a kind of rush root, that of an unknown plant, and of fern were also eaten. The fern roots were dried, laid on a rock, beaten with a bone club into a kind of flour, which was mixed with fish eggs and made into a cake called by the Klallams skive-u.

The young shoots of the thimble-cap, salmon berry, and a plant, name unknown, were and are still eaten; of all these the kamass and fern cakes, as far as I know, were alone put up for future use; neither is now much used.

*Wild fruits.*—The blackberry, three kinds of huckleberry (black, red, and blue), sallal berry, cranberry, gooseberry, hazel-nut, salmon berry, strawberry, raspberry, crab-apple, currant, elderberry, and a small red berry from their tobacco plant, are all used for food. The blackberry, two varieties of huckleberry, and sallal berry are dried for storage, the first being often pounded up and made into cakes. Between the young shoots, roots, and fruits they have some kind of vegetable food most of the time.

*Land mammals.*—The beaver, black bear, deer, elk, otter, wild cat, raccoon, and mountain sheep were used for food, all except the mountain sheep and wild cat being still in use. When a bear is killed it is very common to invite friends and have a feast. The flesh of the deer, elk, and bear is dried.

The crane, grouse, goose, gull, light and dark loon, pheasant, and seven varieties of ducks, viz, the mallard, pin-tail, scoter, wood, teal, diver, and canvas-back, are eaten. The grouse and mallard duck were not eaten until the whites came; the mallard because it fed on snails. None of these were put up for future use, but now ducks are sometimes salted down by the barrel.

Salt was never used until the whites came, and even now they do not salt much of their food. There is no place in this region where salt can be obtained, except in the sea. They did not even have in their language a word for salt, though they had terms designating its quality and also one for salt water. I have occasionally seen them drink salt water with relish, and they may have thus satisfied the demands of nature.

*Cooking.*—Birds and oysters are now generally boiled. Young sprouts are eaten raw. Muscles are roasted in the fire. Fish, when eaten fresh, are boiled or roasted on spits before the fire. Other animal food is roasted on the spit, boiled, or steamed. Berries are eaten raw, stewed, and in pies. In steaming food in large quantities they follow much the same rules as when cooking and opening clams, but dry branches of trees are used in connection with the mats. Formerly in boiling they heated stones and placed them in water in their water-tight baskets.

*Storing.*—Cultivated roots when stored are commonly "cached" in the ground and covered with boards and earth, regular cellars being uncommon.

*Drinks.*—Tea and coffee are now very common, but when not able to obtain these they have occasionally made a tea from the leaves of the cranberry, blackberry, and hemlock. They use but little milk, for while they have some cows they think dairying too much trouble.

## MEDICINES.

I have been unable to obtain a complete list, but give the following remedies, some of which were given in my article on the Twanas:

*Alder-buds*.—Used for colds and biliousness. They eat them and afterwards drink salt water as an emetic.

*Alder bark*.—This they grind in water and drink the infusion as a tonic.

*Barberry bark* is prepared in the same way as the last, and used to purify the blood.

*Blackberry root* is used for colds.

*Cedar gum* chewed for toothache.

*Cedar leaves* are chewed and bound on cuts.

*Cherry bark* prepared as alder bark for a physic and tonic.

*Cottonwood bark*, from the body of the tree, after having been soaked in salt water, is ground and used as a medicine.

*Cottonwood buds* are also used as a medicine.

*Crab-apple bark*.—A cold tea is made from this as a wash for the eyes.

*Elder bark*.—An infusion taken internally and in a vapor bath is used for diarrhœa.

*Licorice*.—Used for colds.

*Oregon grape*.—The root and bark are used in the same way as alder bark for skin diseases.

*Rose bark and roots*, used as medicine.

*Potatoes*, scraped, for burns and scalds.

*Skunk cabbage leaves*.—They heat rocks, throw water over them, place leaves on them, and get over the steam for strengthening general debility.

*Earth* is sometimes bound on bruises.

*Cautery*.—Rheumatism is sometimes treated by taking a red-hot iron, stick or small bunch of cedar bark, and burning the flesh to the bone.

*Blood-letting* is done by scarifying the body in various places.

## HABITATIONS.

*Dwellings*.—Their houses are of nine kinds. The potlatch houses are the only public houses which they have. They are not constructed on a uniform plan. In the account of potlatches will be found a description of a house on the Skokomish Reservation and another at Dungeness. One built by the Twana Indians, ten years ago, was somewhat similar, to the one on the reservation, but was larger, being about 50 feet wide and 300 feet long. One at Port Angeles was also somewhat similar, and these were used very little as dwellings after the potlatch. Those at Sequin and Port Gamble are more nearly like the one at Dungeness, and have since been used as dwellings.

*Sweat houses* are very uncommon; the only ones which I have seen have been used by the medicine men. They are 3 or 4 feet in height



and a little more in diameter, being conoidal. Sticks are driven into the ground near together, bent over, covered with large leaves, as those of the maple tree, and then covered with dirt. They are only intended for one person at a time.

*Large dwelling houses.*—These are usually 25 or 30 feet wide by 40 or 50 long, though occasionally they are made 80 or 100 feet long. They are each owned by one man, but intended for several families, usually his friends and relations, who pay no rent. There is no floor. The doors are either at each end or in the middle of one side, and inside the house there are small walls on each side of the entrance, similar to that in the potlatch house, to guard against the wind. Each corner is intended for one family, but sometimes more occupy it. On the inside, all around the building, there is a bed platform about  $3\frac{1}{2}$  feet wide and 2 feet high. A part of this is used for storing their effects. Underneath it, also, many things are kept. Below and in front of it is a low seat about 6 inches high and 3 feet wide, which is also sometimes used as a place for sleeping. The fire is on the ground in front of this and the smoke escapes by holes in the roof immediately over the fire and about 7 feet above the ground. Sticks are placed in various positions where food, especially fish and clams, are hung to dry. This class of houses is now used very little by the Twanas.

*Flat-roofed dwelling-houses.*—The sides of such houses are made both of upright and horizontal boards, and the roof is composed of two parts, that made of split cedar boards or clap-boards, which generally have a steep pitch, and another part made of long boards. Such a house is intended for only one or two families, and the inside arrangement is very similar to that of the large dwelling-house.

*House with roof wholly on one side.*—In this the roof is similar to that of the last. This is said to have been anciently the almost universal mode of building all permanent houses, and the boards for the roof were hollowed out. This form of house is now seldom used.

*The Government houses.*—These were built on the reservation for the Twanas by the Government carpenter, the Indians having been induced to use a part of their annuity money to purchase the lumber, and are now the dwellings most in use. A number of the Klallam Indians have also built similar structures for themselves. These houses are mostly 16 by 22 feet, with a shed kitchen 8 or 9 feet wide added on one side. Inside they are generally divided into a bed-room, sitting-room, and kitchen. Some of the rooms are papered and are furnished with beds, tables, chairs, benches, a cupboard, and a stove or two, and a few either have mats, a few rugs, or pieces of carpet on the floors. They have also clocks, dishes, looking-glasses, etc., and in one there is a bureau.

*The mat house.*—These are made of mats, and of late some boards are also used in their construction. They are intended as temporary houses and are generally put up at fishing places during the summer. Inside,

the beds are laid around the side on boards a few inches from the ground. The fire is in the middle; most of the space overhead is occupied with fish which are being dried. People and things are stowed where any room can be found, and the whole atmosphere is filled with smoke.

*The half-circle camp.*—When traveling in stormy weather they often place poles in the ground in the form of a semicircle to the windward and fasten mats to them, the whole standing so as to answer both as wall and roof. Under this shelter they sleep. The fire is to the leeward, which is open.

*Tents of cotton cloth* are now often used in travelling, and sails are also spread over poles so as to form a kind of low tent.

*Outbuildings.*—These consist of barns, stables for horses, stables for oxen when they are logging, cellars and caches for roots (chiefly potatoes), woodsheds, which are also rather scarce. They often take their canoes into their large houses. These outhouses are all built after the style of those of the whites, though not usually as substantial. None of them were in use, as far as I know, before the coming of the whites. Their houses were originally near the beach in small villages, but arranged with no order. Those at Jamestown are now on one straight street and those on the reservation on their farms.

#### APPURTENANCES TO DWELLINGS.

*Doors.*—These are opened or closed by sliding boards over the aperture. At present all doors are made after the civilized style. Sometimes only mats are hung over the entrance.

*Fire-places.*—These are of five kinds, two of which are ancient and three modern. (1) Anciently the Klallams, at least, dug a place about a foot deep and 5 or 6 feet in diameter in some of their houses, heaping up the dirt around the edge. There are none of these now in use. (2) They build their fires on the ground without any preparation but a smoke-hole. This is usually about 3 feet square and often has a cover which may be used when a severe rain occurs or the occupants are absent. In the Government houses a hole is sometimes cut in the floor about 3 feet square; the space from the ground to the floor filled with earth, and perhaps the edges of the boards around the fire lined with tin. In the flat-roofed houses a board or two is removed at one end, or for the whole length, in order that the smoke may escape. A board chimney is sometimes used, which is the connecting link between the fire on the ground and our chimney. The hearth is of earth, the sides simply of boards nailed up. Its peculiarities are its size and material. It is built large for two reasons: First, that the boards may not take fire, and as an additional preventive sometimes an old piece of iron is placed against the sides of the chimney. Second, that the occupants, especially when sick, may lie inside the chimney near to the fire.

A common-sized chimney of sticks and dirt is sometimes built similar

to those of the whites in the new settlement. Another form from the logging camps of the whites is a truncated pyramid placed so that the base, which is about 5 feet square, hangs some 5 feet above the fire and the smaller end passes through the roof. The draught through this is sufficient. Such a chimney is placed near the center of the room, so that occupants can gather around the fire.

*Material for building* in all permanent buildings is of wood, and of late years sawed boards are usually obtained. Barns are often sided with split cedar boards from 3 to 5 feet long, called roof-boards, clap-boards, or shakes. Formerly their large planks were split from cedar trees, and, as cedar decays slowly, this is still in use in many places. The largest I have seen were among the Klallams at Elkwa, and they were  $2\frac{1}{2}$  feet wide and 40 long, and  $3\frac{1}{2}$  wide and 20 long. These were split, and afterwards trimmed by hewing.

#### FURNITURE AND UTENSILS.

*Mats.*—These are of seven kinds. Three kinds are made of cat-tail rush. The plants are cut by the women in July and August, dried in the sun, and tied in bunches as large as can be comfortably carried. When a woman finds that she has time to make mats she assorts her rushes according to size into three lots. Of the largest rushes she makes the largest mats, about 5 feet wide; of rushes of medium length she forms mats about 3 feet wide, and of the smaller stalks she weaves mats about 2 feet wide. All these may be of any desired length. The largest mats are used chiefly for lining wooden houses and in constructing mat houses. Those of medium size are used at times for the same purpose, for the half-circle camps, for beds, pillows, seats, table covers, and as substitutes for umbrellas and oil-cloth, two layers forming an almost complete protection from the rain. The narrowest mats, usually from 3 to 4 feet long, are used mostly for cushions, as in canoes, and for the paddlers to kneel on. These cat-tail mats are thus made: The ends of the rushes are first fastened together in the shape of the mat, then strings made of the same material, shredded and twisted, are passed transversely through these rushes, and about  $2\frac{1}{2}$  inches apart. This is done with a needle of hard wood 3 feet long, half an inch wide, three-cornered, and with an eye in one end, in which the string is placed. After the string is passed through, a small piece of wood with a crease in it, is pressed over the mat where the strings are, to render it firm and of good shape. The edges of the mats are fastened by weaving the ends of the transverse threads firmly together.

Another mat is made and used in a manner similar to the medium-sized cat-tail mat, but it is made from a round rush which usually grows to a height only sufficient to make mats about 3 feet wide.

A rough mat is made from the inner bark of the cedar, split into strips half an inch wide or thereabouts and woven together at right angles. It is used chiefly to lay fish upon when they are cleaned.



A mat is also made from the inner bark of the cedar, which is split into strips a quarter or a third of an inch wide and woven in a manner similar to the last, but much more firmly and with more carefully finished edges. Sometimes a portion of the strips are colored black and woven in at regular distances, or else a border is made of the black strips. These mats are usually about 4 feet by 7 or 8, and were formerly used for sails, but are now used for house lining, matting, and to place food on at feasts.

Small table mats are also manufactured, much more as an article of commerce for the whites than for their own use.

*Baskets.*—These are of eleven kinds. They are woven and sewed, and are made of grass. They usually hold from a pint to a half bushel and are used for the following purposes:

(1) Carrying water and juicy berries, and formerly for cooking by placing heated stones in them.

(2) A stiff basket, but not water-tight, about the same size as the last, is made from nearly the same material, but not sewed. These are for more delicate use.

(3) Baskets made of cedar limbs split, the bark usually taken off, are woven. They hold commonly from a half bushel to a bushel. Those whose capacity is only a half bushel are ordinarily used for rough work, such as carrying fish, potatoes, clams, muscles, and roots. The upper loops are made also of cedar twigs twisted, and in these the carrying strap is fastened.

(4) The fancy basket is made of small grass and usually ornamented by figures. It holds from 2 quarts to 3 pecks, and is generally used by the women for storing clothes and fancy articles of the house.

(5) A basket made of a bush split and shaved on both sides. The pieces are a third or half an inch wide, and are woven together at right angles. It is used more by the whites than the Indians as a clothes basket, and seems a copy of some American baskets.

(6) Baskets made of the cat-tail woven, and usually holding about a bushel each. They are not durable and not much used, and chiefly for storing their effects.

(7) A large carrying basket somewhat angular and used in much the same way.

(8) Small baskets, usually holding not over 2 quarts; they are made of small grass, obtained by the Makahs, and used by women for holding sewing materials and similar small articles.

(9) Baskets made of the inner bark of the cedar, split into strips a half or third of an inch wide and woven. They are of various sizes, holding from 2 quarts to a bushel or more; used for storing purposes.

(10) Baskets made of some kind of grass, holding about a bushel, and really more of a sack than a basket; used as the last.

(11) Another similar to the last, but made of another kind of grass; also used for storing purposes.



Of these Nos. 1, 2, and 3 are common to these tribes, both in manufacture and use. Nos. 2, 4, and 6 I have only seen among the Twanas. No. 10 is made by the Quinaielt Indians, and is imported by the Twanas. No. 11 is made by the Klikitat Indians, and is also imported by the Twanas. I have never seen the Klikitat baskets among the Klallams or Chemakums.

*Boxes.*—I have only seen two kinds of boxes which are peculiar to these Indians. The water-box, which is made perfectly tight with the exception of a hole in the upper part, where the water is poured in, and the one from which it is poured out or drunk. The size of this is usually about 8 inches square and of the same length. This and the water-tight baskets are the only native water vessels, as far as I know. The box has the advantage of keeping out the dust. The second kind is used to keep shell money and small valuables. This consists of two parts—the box proper and the cover, which fits over it to the bottom. Such boxes were formerly made large enough to contain blankets. The construction of both of these boxes is similar and somewhat peculiar. The sides and ends are made of one board; where the corner is to be a small miter is cut, both on the inside and outside, partly through. Then the corners are steamed and bent at right angles, and the inside miter is cut so perfectly that it fits water-tight when the corners are bent. The corner where the two ends of the board meet are then fastened with wooden pegs driven in diagonally. The top and bottom of the box are fastened with pegs similarly inserted. (See Eell on the Twana Indians, p. 69.)

Dishes are used mainly for holding fish and seal oil. They are made of wood, alder being preferred. One made by the Indians of British Columbia, and which found its way among the Twanas, is made of the horn of the mountain sheep. There is no paint on it, but all the figures are made by carving, the darker shade representing the deeper cut. Some of these dishes were evidently made for holding food as well as oil. The intestines of seals, deer, and some other large animals are also sometimes used for holding oil. At present the Klallams chiefly use them.

The water-tight baskets already described were formerly used for stone boiling. Two kinds of spits are now in use for roasting. One is a simple straight stick, nearly round, half an inch or less in diameter, from 1 to 2½ feet long, and sharpened at both ends. By using several of these, some set at right angles to the others, a salmon is stretched out so as to be either dried or roasted. On a single one clams are impaled and dried, and smelt or other small fish are roasted. The other is a stick about three-fourths of an inch wide, 1½ inches thick, and 3 or 3½ feet long, which is split for about 2 feet and then tied with grass to prevent its splitting further. The three ends are sharpened. On the two smaller ones the fish is fastened, and the other is stuck into the ground before the fire.

*For serving and eating food*, the following utensils are commonly employed:

*Mats*.—Some of these are often placed on the ground during feasts and the food placed on them, the guests seated on the ground on each side.

*Baskets*.—Berries are often served in the water-tight baskets.

*Plates and troughs*.—These are made of wood and are quite shallow. Alder wood is preferred. They are generally from 9 to 12 inches wide, and from 16 inches to 6 feet long and 10 inches wide. Of late years, since lumber has become common, troughs 6 inches wide and from 8 to 12 feet long are made of boards. They are for use during the large feasts, food being placed upon them. Rice, boiled fish, and semi-liquid food are now generally served from American kettles, plates, and pails.

*Trays*.—Occasionally trays are made. I have seen one 40 inches long, 25 wide, and 7 deep, and others smaller.

*Ladles*.—These are made both of wood (maple) and horn. These ladles are used for semi-liquid food; but are not always placed in the mouth, but near the mouth, and the food is pushed from them into the mouth with a small stick, or taken from them with a smaller ladle, which is placed in the mouth.

*Stone dish*.—The only stone dish I have seen was obtained from the Klallam Indians of Port Angeles. It is said to have been used for holding oil while eating it. It is a quarter of a sphere and quite regular. Another one was found while plowing at Port Angeles. It is a half-sphere, made of clay stone, and the Indians are not certain that it was ever used as a dish, as many similar ones are found at Klallam Bay. Its upper edge seems to have been trimmed for use.

*Pipes*.—The only two stone pipes which I have seen, appear to have been made from a soft grayish stone, perhaps clay stone.

I can not learn that pipes or narcotics were used by these Indians previous to the coming of the whites. When tobacco is scarce they often mix with it the leaves of a small bush which has a red berry, called *ska-wail-dai* by the Twanas; *ské-wad*, by the Skwaksins, and *stain-swot-man-ish*, by the Klallams. Tobacco is used by the majority of this people, but they are not as much addicted to it as some other Indians. I have seldom seen them chew it. The Twanas rarely smoke it except at some gatherings. The Klallams use it much more freely than the Twanas. I have never known of their smoking the pipe of peace.

*Napkins* are seldom used except at great feasts. One form is made of cedar bark, slightly beaten, about 2 feet long and tied into bunches an inch in diameter. I have seen also a piece of calico stretched by two individuals from end to end along a row of feasters, near their mouths, on which they wipe their hands and mouths when done eating.

*Miscellaneous*.—Fir pitch wood is generally used for torches, and when this is wanting, cedar is split somewhat fine and a handful of it lighted, but the lights of the whites have nearly taken the place of these rude lights, except for fishing and duck hunting night.

## CLOTHING.

*Hats.*—A hat made by the Makahs, but which finds its way among the Twanas and Klallams, is water-tight and seems to be made in a manner somewhat similar to that of the water-tight baskets. Other hats somewhat like these, but with flat tops, are made by Indians of British Columbia and imported. None are made by the Twanas, Klallams, or Chemakums. They commonly go bareheaded.

*Body clothing.*—Pantaloons, shirts, and coats were formerly made of buckskin by these Indians, but are not now. The only buckskin clothes I have seen were imported from the Chehalis and Takania Indians. Short skirts for the women were made of cedar bark finely split and bound together at the upper edge where they were fastened around the waist.

*Blankets.*—Three kinds of blankets were formerly in use. One was made of dogs' hair, geese feathers, and the head of the cat-tail rush, twisted and woven together on a loom. A kind of dog, rather small, was kept specially for its hair, which was very long, and a woman's wealth was esteemed by the number of such dogs owned.

Another blanket was made by them from the inner bark of the cedar, slightly beaten and woven, the strings made of geese feathers. Skins were often used, especially those of the bear, deer, and wild cat, several of the latter being sewed together. Hardly any of these articles of native clothing are now worn, the civilized style being adopted.

*Mat coats.*—One kind of coat made of mats was short in front, extending only about as far as the elbows, but long behind, with a hole for the neck, it being put on over the head.

*Arm clothing.*—I have not been able to learn of any special covering for the arms, as some part of the body clothing already described would naturally extend over the arms.

*Leg and foot clothing.*—Moccasins were occasionally used, but the climate is too wet to admit of their being worn with comfort. They generally went barefooted, and the old ones still adhere to this custom.

*Parts of dress.*—A few women have of late learned to make lace from thread.

There is a native-made iron fastening for shawls and blankets. Such fastenings are also made in a little different shape and of brass and wood. Formerly they were made of bone. Fringes are appended to the leather coats, shirts, and pantaloons already mentioned. This is made of leather an inch or two long.

*Receptacles for dress.*—Baskets, described in the previous section, are all used for receiving clothing, except the eighth one mentioned, which is for thread and nicknacks.

## PERSONAL ADORNMENT.

*Tattooing.*—In tattooing they use a needle and thread, blackening the thread with charcoal and drawing it under the skin as deeply as they can bear it.



*Head ornaments.*—Head-bands made of dentalium shell. Threads are run through the shells, then through the leathers which keep the shells in their places.

*Ear pendants.*—There are two kinds, one of dentalium shells, a number of which are fastened together in a bunch. Small pieces of black or red cloth are often fastened to the lower part of the shell for greater ornament. Another is made of abalone shells. Both of these were formerly used as money.

*Neck ornaments.*—Necklaces were formerly made by stringing both the dentales and olivella shells, but such are little used now. Sometimes these strings were 5 feet long, and were doubled several times. Beads of various colors, shapes, and sizes, some being very large, have now taken the place of shells. Blue ones are the most common, being preferred when the whites first came; but of late their taste is changing, and other colors are being used. Dog-fish bones and bears' claws were also strung for necklaces, the latter being used as charms.

*Ornaments for the limbs.*—Bracelets are made of washed iron and brass of native make, and of silver and other material made by the whites. I do not know that any were used previous to the coming of the whites.

*Toilet articles.*—Single wooden combs are common. I have seen only one double one; this was found on a grave at Elkwa, and the handle was partly gone, the whole being decayed. One was found near Port Angeles of horn.

#### WORKING IMPLEMENTS.

*Knives.*—A knife in very common use and of native make has the blade of steel and the handle bone. It is especially convenient in finishing canoes or anything hollow.

Another hunting-knife of native make has a double-edged steel blade, and the handle is of two pieces of bone rivetted around the steel, which extends beyond the handle.

*Axes and adzes.*—At present they use the American adzes and axes, with one exception. Stone axes belong to the archæology of the country. One of this class I have seen, which was obtained in a shell-bed at Dungeness among the Klallams. It was of metaphoric rock, three-fourths of a pound in weight, nine-sixteenths of an inch in thickness, and the edge is ground twice as much on the flat side as on the other. Another specimen found near the same place was of the same thickness; weight one-half pound, and the edge ground a little more on the flat side than on the other.

Some Indians say that these axes were used as hatchets or axes for ordinary chopping and there are trees near Dewater and Doswailopsh, on Hood's Canal in the Twana country, that have been partially or wholly cut by such axes. Others say they were used as hand adzes with which to finish canoes after they had been hollowed by burning. Such adzes are now in common use, only they are invariably made of old



rasps and hafted with wood fastened together by a thong. All but one appear to be flattened at least on one side and some on both sides, and evidently intended to be hafted in that way. They are all well polished.

*Wedges.*—Large wedges were and are still made of wood. At present those of iron regularly made for the purpose, or old iron ax-heads, are very commonly used.

*Chisels.*—Those of American manufacture are now wholly used. I have seen only two of native make. Hammers of American make are also chiefly used, though occasionally stone tools are employed.

*Implements of special use.*—The number of stone axes, hammers, etc., which still remain among them show that some tools were used in their construction, but I have seen no such tools and heard of none, except that some say one stone was used to break, grind, and polish another. Their bone knives must have been used for making bows and arrows. There was but little need of implements for straightening arrows, as both cedar and iron-wood are naturally straight enough. For fastening the feathers and heads to the shafts a string of some thin bark like the hazel bark is used, and in securing the heads the string is covered with pitch of the red fir. Their fish-spear heads are fastened in the same way. The ends of the bows are bent by being wrapped in sea-weed or moss and buried in the warm ground very near the fire, where they steam, after which they are easily bent. Nettle strings and entrails of deer and the like, properly prepared, were used for bow-strings previous to the coming of the whites.

#### WEAPONS.

*Striking arms.*—Clubs were used for striking, especially when the Indians creep up by night in some stealthy way and surprise their enemies. One found near Dungeness had a whale-bone handle. The carvings are intended to represent the head of the thunder-bird, an emblem of power. Wooden clubs were also used.

Slings and shots or stones are used only by boys as playthings, and formerly by young men in killing ducks.

Fire-pots, filled with pitch wood, were formerly used to set houses on fire into which the enemy had fled. A part of the besieging force would attack one side of the house in order to draw the attention of the besieged away from the opposite side, when the party with these fire-pots would approach, set fire to the pitch wood, throw it on the roof, and as the besieged attempted to escape they were killed with spears, clubs, knives, or were shot.

*Thrusting arms.*—Spears for hunting ducks have usually a handle 15 or 20 feet long, and the prongs so far apart as not to injure the body of the bird. The teeth of the prongs are on the outside so as simply to catch in the feathers. These were formerly made both of bone and hard wood, but iron has been substituted for bone. A school-boy wrote

me that ducks are caught with these spears at night by the light of a fire kindled in the back of the boat, which is generally occupied by two men, one to use the spear and the other to paddle. Geese and fish are also caught in the same way. Sometimes in foggy weather these Indians cover their canoes over with green boughs, among which they hide, then they paddle quietly among the ducks and shoot them.

*Bows and arrows* were formerly their only weapons of the projectile class, but they have been almost entirely superseded by guns. The shaft of the arrow is either cedar or iron-wood; of late many of the heads are made of wire of about three-sixteenths of an inch in diameter and 5 or 6 inches long. Chalcedony and basaltic rock were also used in their manufacture, but stone arrow-heads are very scarce. The Indians have a tradition that they were made by the wolf or panther while those beasts were men, before being metamorphosed by Dokibatt. They also say that when broken into small pieces and shot at men or animals they are sure to cause death. This tradition, taken in connection with those of Dokibatt, is about all that seems to point to the existence of a race inhabiting this country previous to these Indians.

*Armor.*—The only bodily protection against the missiles of enemies of which I have heard is a kind of shirt made of dried buckskin covering the body.

#### FISHING IMPLEMENTS.

*Spears and hooks.*—Living as they do on Puget Sound, a great portion of their food has always been obtained from its water. The Klallams practice nearly all the methods which the Twanas have for catching fish, and also have some additional devices, as there are halibut, seal, and whale living in the waters of the lower sound which are not found in Hood's Canal. They have now adopted most of the methods practiced by the whites, especially the use of the hook and line. They buy hooks of European make, and also forge them from iron or steel. They have fish-spears made with three prongs, and sometimes with only two. The handles of such spears are usually of fir, it being both strong and straight, and the prongs are of some hard wood, as maple or iron. They are used for spearing flounders, crabs, salmon, and the like, and bringing up fish eggs. When doing so one person paddles while another uses the spear, and, because of long practice, they will see a fish partly buried in the mud, and having seen one, they hardly ever miss spearing it. There is a hook made of iron, but which is fastened to a pole 15 or 20 feet long by a thong or two. The end of the pole fits into a piece of wood which is fastened around the hook. By means of the pole the hook is moved around in the water and hooked into a fish, but when the fish is caught the pole is pulled out and the strain is on the thongs. The double herring spear or rake is made of wood, 15 or 20 feet long, with nails fastened into the lower end, usually only on one side, making a single herring spear, but occasionally on both sides. The nails are all sharpened. Another form of spear-head

or native hook is worked in much the same way as the last. It consists of two spear-heads, the sharp point of each being of iron (formerly bone was used). This is fastened to two bones or pieces of hard wood by strings covered with pitch, and the whole is then fastened by strings or thongs to poles which also fit into the hooks.

There are several fishing implements used only by the Klallams, since the prey they are designed to capture, viz, halibut, whale, and seal, valuable for its furs, are not found in the Twana waters. One is a halibut hook made of a piece of bone and fastened by strings of cedar bark to a piece of hemlock wood bent by steaming to the required shape.

There is also a cod-fish hook. The head is of bone fastened with bark to a piece of whalebone. The bait, which is often a small fish, is slipped over the end; hence the necessity of a loop by which it is fastened to the line. The lines used with this hook are often of fine root-lets of the kelp, which when dry are brittle, but when wet are very strong.

These lines are used for various kinds of fishing by the Klallams, but are not used by the Twanas, as the kelp does not grow in their waters. Another, used for seal and whales, has a steel head which fits over a wooden handle to which it is fastened by thongs. The lower Klallams alone know the process of catching seal, and they have to go to the Makah waters for this purpose.

*Traps and nets.*—A way of taking salmon in rivers is to build a trap across the river. A number of small sticks three-fourths of an inch in diameter and  $6\frac{1}{2}$  feet long are fastened together 2 inches apart. Long sticks are placed across the stream and secured by braces. The small sticks or weir are placed so as to lean against these larger ones, the upper end slanting down-stream and tied to the poles; while for additional security the gravel of the bed of the river is shoveled on around the bottom of them. The weir prevents the fish from ascending the stream. Nets are then provided, about 6 feet broad and 2 feet deep, made of strings and secured to a rim of wood. Native strings of this sort are made of nettle or alder bark twisted, but American twine is now often used. During the day-time these nets are pulled up, but let down at night, when the fish are running, one man watching each net. The fish striving to ascend get into these nets, and their presence is immediately known by the moving of the string. The net is then pulled up, the fish killed with a club and laid on a platform. These clubs are often common sticks, but are sometimes fancifully carved. There are usually four nets let down at once to form the trap. Another trap is made in a similar way as regards the weir, but otherwise differing across the stream. Up-stream from the weir several pens are built, in which doors are made V-shaped, opening from below. The fish easily enter this, but, unable to find the way out, are speared.

Salmon in the salt water are also taken with seines, either bought or made by the Indians. In making them they wind the twine on a frame



or bobbin of wood, which is open at the ends so as to receive the twine. The knots are tied over a block so as to secure interstices of uniform size. Another form of net, for gathering sea eggs and small fish, has a handle about 10 feet long and the rim of hoop-iron.

A sinker of stone is not manufactured, but a water-worn stone of the right kind is found on the beach and bark is fastened around it, to which the line is attached.

#### INDUSTRIAL PROCESSES.

*Leather-working.*—The deer or elk hide is soaked for two days and the hair removed by scraping it with a rough iron. It is then soaked a half day with the deer brains in hot water over the fire, the brains being rubbed over something like soap. It is then stretched and rubbed with rocks until it becomes soft and pliable, when they dig a hole in the ground, build a fire of rotten wood or cedar bark, stretch the skin over it and cover it with blankets, thus smoking it, after which it is fit for use. The stick on which the skin is placed to remove the hair is 4 inches in diameter, but on the under side about 1 inch is taken off. An irregular broken stone, fastened to a wooden handle, is used for rubbing the skin to render it pliable. The handle is about  $3\frac{1}{2}$  feet long. Sometimes, though, the stone is used without being fastened to a handle, being simply held in the hand. This one is about an inch thick.

Sticks of various kinds, and sometimes irons about 2 feet long, are used for digging roots, clams, etc.

*Basket-working.*—A bone implement is used for pressing the parts closely together in weaving baskets. Such tools are also made of hard wood. This and an awl for sewing the water-tight baskets are the only tools I have seen used in this work.

*Implements for working fiber.*—There is a wooden hand-spindle used now for making woolen yarn, but formerly for making yarn of other materials to be woven into blankets. This implement consists of a slender stick fixed in the center of a circular disk or wheel about one-fourth of an inch thick. The material to be spun is fastened to one end of the stick, the opposite end is taken in one hand and rolled over and over in the lap, while the other hand holds the yarn, which made in this way is very uneven. Occasionally very inferior yarn is made in this way by twisting the material with the hand on the lap. American cards are now used, and spinning-wheels have been introduced to some extent.

A loom secured to the ground by its pointed feet was formerly used in weaving blankets, but it is now occasionally used in weaving rugs.

*Painting.*—Before the introduction of American paints, black paint was made from coal, which is still used as a cheap paint, especially when painting the face; one kind of red paint was made from a red clay obtained by the Twanas about 6 miles below the reservation on the east side of the canal. There is a tradition about that clay as follows: "Long ago, before Dokibatt came, this bank was the Klikitat Indians



and the opposite side of the canal was the Twanas. There was a gambling contest between the two tribes, and the Klikitats won the game. When Dokibatt came he changed them all to land. For this reason the Twanas use the red paint as a charm in dancing, gambling, and tamanous; for this reason also the Twanas are still beaten in such contests with other tribes; *i. e.*, once overcome, always overcome." Another red paint was made from the gnarls of a certain kind of tree found in the mountains; the wood passed through some kind of process under the ground.

The juice of berries is also sometimes used for painting faces.

A white or yellowish paint is said to have been made by burning elk horn, powdering it, and mixing it with oil. A clay-colored paint was made from a kind of earth in the Twana land. The Klallams obtain their red paint from a red clay in the Makah land; it is burned and mixed with dog-fish oil.

*Dyes.*—Cedar bark and grass is dyed black for ornamenting baskets by being buried in the black mud of the salt marsh for two days. To color the same yellow they are boiled with the bark of the root of the Oregon grape for a short time. To color them a deep red they are soaked with alder bark. Baskets are imported from the Makahs in which the grass is dyed purple, crimson, blue, and two shades of slate.

*Sand-paper.*—The skin of the dog-fish is used for this, and it is very serviceable.

*Ropes and strings.*—The largest ropes I have seen made by these Indians are of cedar twigs twisted in much the same style as our own hemp ropes, but they look coarser. These are very strong and lasting. The largest are made on the buoys employed in catching seal, and are three fourths of an inch in diameter. Some one-half inch in diameter are used for fastening canoes, and those three-sixteenths of an inch are utilized in fastening cross-pieces to canoes. Of braided cat-tail they make a flat rope, not very durable, about three-eighths of an inch thick by three-fourths of an inch broad, which is used for tying paddles into bundles, and of the beaten fiber of the same material twisted they make strings from an eighth to three-sixteenths of an inch thick, which are used in sewing mats together. They are not very strong, but for this purpose are good enough.

The ropes at the ends of the head-bands used in carrying baskets are made of the bark of the alder braided. They are about three-eighths of an inch thick and five-eighths broad. Of the inner bark of the alder split and twisted a kind of string is made which is manufactured into fishing nets. Another string one-sixteenth to one-eighth inch in diameter, also used in making nets, is made by hackling and twisting the outer fiber of the nettle. This is strong and looks much like linen twine. The Klallams make, without special preparation, lines out of the smaller part of the help root of about one-eighth inch diameter. When dry it is brittle, but when soaked a short time in water it becomes quite

strong. Flat grass and strips of bark from an eighth to a half inch wide are also used in various ways, especially in making arrows and fishing implements.

Ropes used as hitching ropes, bridles, etc., for horses are made by braiding the long hairs from the horses' manes and tails. They are made about a half inch in diameter and are very strong and durable. Elk, deer, and other skins, both dried and tanned, are cut into thongs which are used for various purposes. Fibrous tissue from the deer, the elk, and the whale is used in sewing.

*Other processes.*—Obtaining oil from the liver of the dog-fish by boiling has become quite a business, as the oil is in demand by the loggers. Gathering oysters and clams, halibut and salmon for American canneries occupies a number. The Twanas are engaged in farming more than the Klallams and more in logging, but the latter work more in saw-mills than the former.

#### LOCOMOTION AND TRANSPORTATION.

*Travelling by water.*—This is the chief mode of travel by these Indians, as their land is all situated on the shores of the sound, with its bays and inlets. The Klallams are more confined to it than the Twanas, owing to the mountainous character of their country, which makes it impracticable to visit by way of land any other Indians, while the Twanas are obliged to travel at least 10 miles southeast by land in order to reach the waters on which the Skwaksins live, and 30 or more to the south to reach the Chehalis Indians, with both of which tribes they have considerable intercourse. Trips to these tribes, and occasionally to Olympia and the Nisqually country, 40 miles to the southeast, together with their hunting excursions, constitute the sum of their land journeys. All other travel is by water. The Klallams own larger canoes and are better navigators than the Twanas, as they live nearer the mouth of the Straits of Fuca, where there is less protection from the ocean winds than in the Twana waters.

On January 30, 1878, I started with about sixty-five Twana Indians, in seven canoes, to attend a potlatch. We paddled until it began to rain, and also to blow favorably, so that nearly all, except those who steered, spent the time in trying to keep dry. A few had oil-cloth coats, a few umbrellas, but the most of them used their common mats, which are almost water-proof. It was rather comical to see a number of persons, mostly women and children, sitting in a canoe with a mat stretched over them, extending almost from one end of the canoe to the other. From a side view, only their heads were visible. Towards evening, after travelling seven and a half hours, and making a distance of 30 miles, we arrived at Seabeck. The next day it rained heavily until noon, and they decided not to start again on the voyage until the following day, as there was a head wind which would prevent their reaching a shelter before night, and moreover they did not wish to be the

first at the potlatch. Some of them made a fire of pitch wood and cedar on a board, then putting their canoes on blocks, about a foot high, they placed the fire underneath, moving it along the whole length of the canoes, so as to burn off the moss and other material which might have accumulated on the outside of them, but not leaving the fire long enough in one place to burn the canoe. They do this to make the canoe run more easily. On Friday morning the messenger came to me at 7 o'clock, saying they were about to start. I hurriedly ate a part of my breakfast, and taking the remainder in my hand I started to their canoes. Four of them had gone, but the one in which I was travelling had not even been loaded. This it took them fifteen minutes to do. Then it was said one of the company was sick, so they stopped to tamanous over him, and it was half past 8 before we started. One more canoe, with ten persons, was here added to our company. The wind blew favorably and strongly, as much so as our crafts would bear. There was a fellow-feeling among all, for no single canoe of either set of four was allowed to be far away from the rest, for fear of some accident. If one could not keep up, the rest waited for it.

In eight hours we travelled about 35 miles, and arrived at some Indian houses, where all camped within 3 miles of Port Townsend. It had rained most of the day. We did not stop for dinner, but all ate a little dry lunch at noon. At morning and night they had warm meals. The next morning they had a short tamanous to obtain fair wind and weather. It consisted of singing, pounding on the drum, and on sticks. About 8 o'clock we started and reached Port Townsend in about an hour. Here they spent nearly two hours in purchasing things to present to the principal men at the potlatch, and the day being pleasant we went on, having a race in which nearly all the canoes took part. As there was little wind it was a trial of strength and endurance, and was engaged in for mere sport. It was kept up for 2 or 3 miles, until one canoe had passed all the rest and the losers were satisfied that it was useless to contest further. At about half past 5 we reached our destination, having made the entire trip in twenty-two traveling hours.

We set out on our return to Skokomish on the 11th of February at 11 o'clock. They intended to travel only 6 miles, camp at Sequim and visit these Indians, but the wind and weather proving favorable, they passed Sequim Bay without going into it, and encamped within 5 miles of Port Townsend. They would have gone farther, but the wind was blowing so strongly they were afraid to round Point Wilson, which is a dangerous place when the sea is rough. Here they camped out, away from houses, for the first time on the trip. This they often do in summer, but not so in winter if the women and children are along. It was a calm night, and they did not make much preparation for camping. Some slept in their canoes, but most of them lay on the ground, and some fixed up their sails and mats so as to shelter themselves from the wind.



The next morning I was up at 6 o'clock and called them, but they heard the wind blowing and thought it would not yet be safe to go around Point Wilson, so they did not get up, but in an hour it had calmed down and they concluded to start; fearing though that it would rise again (as it did soon after), they rose and started without any breakfast. Reaching Port Townsend they remained there until about noon. Then most of them went 3 miles farther and camped; but the owners of the smaller canoes feared to go across the bay, as it was very rough.

About 8 o'clock the following morning we again started and to shorten the distance some of our party took a route where we were obliged to make a short portage. Often in doing this, when there are but few persons along, they unload the canoes and take the articles and canoes separately across, but this time there were so many along that they were able to pull the loaded canoes across, having first laid down sticks over which they were dragged. During the day there was another race. We reached Port Gamble about 2 o'clock in the afternoon and some thought it best to proceed, but the Port Gamble Indians invited my companions to spend the night with them and partake of a small feast, which invitation they concluded to accept. The feast consisted chiefly of potatoes and rice, cooked in kettles, around which they sat, taking the food out with their large ladles. After dark the women assembled in one house and sat down in two rows opposite each other, singing for an hour or more, accompanied by the drum and the pounding of sticks. When this was over, two of the Port Gamble women made presents of from 5 to 12 yards of calico to each of Twana women, and after 10 o'clock some of the Twanas and Klallams began to gamble and kept up their game until 3 o'clock in the morning.

The next morning there was another feast of bread, crackers, and coffee, some of which was carried away. It was half past 10 o'clock before we left Port Gamble, hoping to reach Seabeck, 20 miles distant, by night. But soon after starting we met a strong head wind which grew stronger. Sometimes, especially in rounding small points, we used poles to push the canoes. The Indians seldom carry poles for this purpose, but generally use spears. About 3 o'clock in the afternoon the Indians got tired and encamped, only one canoe reaching Seabeck that night, and that was the one which belonged there. The rest were scattered, singly and in groups of from two to four, for a distance of about 4 miles, and were not together again after this; but the Indians were now in familiar waters and no longer felt uneasy concerning the safety of each other. I was camped with a party having four canoes. The wind blew violently that night, the trees constantly falling near us, and it rained so that it was almost impossible to make a fire. A few had tents, others used their sails as shelter, and the rest arranged their mats on poles placed in a slanting direction so as to keep off most of the rain and wind. About 3 o'clock the next morning an unusually



high tide arose, covering all the beach where we were encamped, compelling us to leave. The water was from 6 to 12 inches deep in our camp before we could get our things into the canoes. So we went back to Seabeck for breakfast, reaching the place about 7 o'clock. It was a cold ride, as we were wet, and the wind blowing somewhat against us. We had to take turns at paddling, to prevent our suffering from cold. Other canoes came in later. Remaining here until half past 10 o'clock we again started, and though there was some head wind, we traveled 15 miles more before 5 o'clock, about which time we made camp. Six of our canoes were in company, the other having remained at Seabeck until the next day. That night I witnessed a silent tamarou over a sick woman.

We encamped on as high ground as we could find along the beach, but next morning about 4 o'clock the tide was so high as to compel us to run for fear of being again submerged. The water came only to the edge of our beds.

Some of the canoes started about 5 o'clock and with a fair wind part of the time they reached Skokomish about half past 10 o'clock. Others waited until after daylight and did not arrive until two or three hours later. Thirty-three hours were occupied in our return trip.

In July, 1876, I made another trip over the same route with these differences in circumstances: The latter trip was with one canoe and in the summer. With one man to steer, one to row, and two women to paddle, we left Skokomish about 6 o'clock in the morning and at 6 o'clock we camped on the beach without tents, having traveled 35 miles. The next day, the crew wishing to start early, I gave them permission, and we were off about 3 o'clock in the morning. They took a cold lunch at about 7 o'clock, and at 4 P. M. we were at Port Townsend, 35 miles from the last camp; but the wind was so strong around Point Wilson that they did not dare to venture there, although they were accustomed to the place, for they were Klallams and were at home in these waters. We were obliged, therefore, to remain at Port Townsend all day. The following day the wind died down and they wished to go, but as it was Sunday I forbade them; but on Monday, at 2 o'clock A. M., we continued our journey and arrived at Dungeness about 8 o'clock, having rowed 20 miles that day. We had no favorable wind during the whole trip and made 90 miles in thirty-one travelling hours, though there was little head wind to oppose us.

In returning we started at half past 4 o'clock, and were at Port Townsend by 10 o'clock, where we remained four hours and then set out for Port Gamble, which place we reached by half past 6 P. M. There we remained for the night with the Indians of that place. The next morning, on account of missionary work, we did not leave until 9 o'clock, and during the day we were detained about two hours in the same work, so that we traveled only 32 miles. The next day by 1 o'clock P. M. we reached home, 18 miles farther. Having had a favorable wind most of the time, we made the whole distance in twenty-three traveling hours.

The quickest trip I ever made in one of their canoes was 30 miles in five hours, before a strong wind, and with two sails a part of the time. But at last the wind was so strong we only dared to have one sail. At this time I had a good canoe and experienced navigators, or it would not have been safe. Few of the Twanas would have dared sail in such a wind.

In addition to the tamanous for wind, mentioned in the account of former trips, they would, especially in a calm, when they wished for a fair wind, pound on the canoe with their paddles or strike the water with them, spattering it forward. They also whistled for wind.

*Canoes.*—These are dug-outs made from cedar trees. In making them they formerly burnt them out, and finished them with the hand adzes of stone, but now they universally use American axes and adzes for the first part of the work and the hand adzes of rasp for the second part, although the finishing touch is put on sometimes with the curved knife. After this they are steamed, spread apart at the sides, and fastened with round cross-pieces or thwarts about an inch and a quarter in diameter. Holes bored through the ends of the cross-pieces and the sides of the canoe admit ropes of cedar which keep the cross-pieces in position. A rim or gunwale is often made for the upper edge of the canoe, about an inch in diameter, which can be replaced when worn out. Those in use are of three kinds. Large canoes, which are made chiefly by the Indians of British Columbia, and imported, are used very extensively by all the Indians on Puget Sound for carrying large loads and for dangerous travelling.

One that I saw was 35 feet long, 5 feet wide in the center, with a perpendicular height from the ground of 3 feet at one point, 2 feet 3 inches at another, 1 foot 10½ inches at another, and 4 feet 1 inch at the end. There were two places for masts, and a seat for the one who steers. The head of this kind of a canoe is a separate piece of wood. Such vessels are made both larger and smaller than this one, the largest I have known being the one exhibited at the Centennial Exhibition, which is 60 feet long and 8 feet wide. None as large as these are, however, owned by these Indians, but a few of the Klallams have some very large ones for whaling. The smallest I have seen was about 10 feet long.

*Shovel canoes.*—These are very scarce, even among the Twanas, and I have seen none of them among the Klallams. They are used in much the same manner as the next kind.

*Small canoes.*—These are very common, are made by both tribes entirely of one piece of wood, except that some have the movable rim mentioned, and are used for fishing, river travel, and even for going on the sound when it is calm and they wish to take only a small load. I have travelled 30 miles in this kind on the salt water, but we seldom venture far from shore.

Very few of these Indians own any skiffs or boats of American make, as their canoes are much lighter and easier for them to handle, and be-

ing accustomed to them from infancy they fear no danger, although a white person entering a small one for the first time is apt to be upset, and they have no keels.

Sometimes two of the large ones are fastened together side by side and covered with boards in order to carry a large amount of hay or ferry a horse for a long distance on the sound, but not for crossing rivers, as there are none in the country so wide that a horse can not swim across.

*Poles.*—In travelling against a strong wind, especially around points of land near shore where the water is shallow, or where ascending a swift shallow river, poles about 12 or 15 feet are often used very effectively for pushing; generally they are poles connected with the sail.

*Paddles.*—The most common form in use is a man's paddle and the woman's paddle, a little shorter in the blade and about an inch wider, as the stroke of the men is deep and long, and that of the women quick and more superficial. These are generally made of maple, but occasionally of yew.

The river paddle which is made by the Chehalis Indians and occasionally by the Twanas has the advantage that in rivers where logs are numerous the end fits onto the log and enables the rower to push the canoe where he can not paddle it.

*Oars.*—They knew nothing of these until the whites came. Rowlocks of either wood or iron are now fitted into most of the large canoes so that oars can be used, but paddles are also used in connection. In dangerous waters they lay aside the oars and use the paddles entirely. They often make oars of fir, sometimes of cedar, and sometimes purchase them made of hard wood. The small canoes are propelled exclusively with paddles.

*Sails.*—These are used with the larger sized canoes, and the largest often have two. Formerly the cedar-bark mats were used, but these have now entirely gone out of date, and those of cloth fastened and fashioned in shape and style by the American skiff sails have taken their place. Many sails are made entirely of flour sacks.

*Rudders.*—Very few canoes have rudders fitted to them according to the American style. Most Indians prefer the old way of steering with the paddle, for they can steer and paddle at the same time, and the shape of the stern of a canoe is not well adapted to a rudder. Usually the best paddle is used for this purpose. Formerly, when slaves were owned, it was the business of one of them to steer, for when the wind was fair the others could rest while he was compelled to remain at his post. Otherwise I have not been able to learn that there is or was any place of distinction observed by paddlers. Now the steerer is selected according to circumstances. If the water is rough and the paddling easy, the strongest person and best navigator steers, but if the rowing is hard the strongest persons are put at this work.

*Anchors.*—These were formerly made of stone, but now some kind of

iron is used. Most of the smaller canoes have no anchors, being tied with ropes or hauled on shore.

*Bailing vessels* for canoes are of several kinds, sometimes carved out of alder wood and without handle. Some are made of cedar bark, the handle only being of wood. This is used but very little now. Often the water is bailed out with the hand, and old tin vessels of American manufacture are used.

#### TRAVELLING ON FOOT.

They generally travel only short distances on foot, seldom more than 10 miles, except in hunting. In coming to the Twana potlatch of 1878, however, the Quinaielt Indians came about 100 miles, chiefly on foot. In this short journey they often, the women especially, carry large loads. The way they usually prefer to do this is to take the carrying strap, tie the ends, which are several feet long, around the load, when it is of wood, mats, and such articles, or into the handles of baskets filled with potatoes, fish, apples, and other small objects. They then place the load on the back, and the flat part of the strap around the forehead. Formerly these straps were made of some tough bark, such as that of alder, braided. Now they use straps woven of strings and rags.

*Snow-shoes.*—These are very scarce and are not often used, except for hunting in the mountains in the winter, as the snow is not usually deep nor does it lie long on the shores of the sound.

*Land conveyances.*—Horses are used much more by the Twanas than by the Klallams, but so little by either tribe that they take very little pride in adorning their saddles and trappings. Common American or Spanish saddles are generally used; occasionally their horses shod. For some reason the word for horse, *ste-a-ké-o*, is evidently derived from the Nisqually word *stúk-ai-o*, meaning wolf, but from what resemblance to that animal I have never been able to learn. The same word, *stiakeo*, is found, as I am told, in the Chehalis language, and in all languages of the Sound except the Makah and the almost dead Chemakum.

#### MEASURES AND VALUES.

*Counting.*—The vocabularies for the first ten numerals of the Twana, Nasqually (Skwaksin dialect), Chemakum, and Klallam, are here given; to which for the sake of comparison are added those of the languages of several neighboring tribes which I have gathered from the members of these tribes who are either inter-married or have visited at Skokomish. These comprise most of the languages spoken on the Sound.



	Twana.	Nisqually.*	Snohomish.
1	Dá-kûs.	Dû-cho.	Dû-chi.
2	Es-sa-lî.	Tsá-lî.	Sá-lî.
3	Chó-ûs.	Klé-hu.	Klé-hu.
4	Bú-sûs.	Bos.	Bos.
5	Tsa-liwěs.	Tsil-áts.	Tsil-áts.
6	I-a-pá-chî.	Dyíl-á-chî.	I-láts and I-láchs.
7	Tu-kôs.	Tsoks.	Tsoks.
8	Tû-ká-chî.	Tû-ká-chî.	Tû-ká-chî.
9	Hwáil-î-a.	Hwail.	Hwûl.
10	Ó-pa-dîch.	Pá-dats.	O-lob.

\* The Skwaksin and Nisqually are identical in numerals.

	Chehalis.	Chinook jargon.	Kwi-nái-ělt.
1	Ôt-sěs.	Ikt.	Pau.
2	Sá-lî.	Măkst.	Sá-lî.
3	Chát-lî.	Klone.	Chát-la.
4	Mos.	Lăk-it.	Mos.
5	Tsi-lats.	Kwîn-nûm.	Tsé-luks.
6	Tá-hûm.	Tá-hûm.	Sî-tûch-î.
7	E-tsóps.	Sîn-a-măskt.	Tsops.
8	Tsa-mos.	Stól-kîn.	Tsa-mus.
9	Tó-hu.	Kwist.	Tûg'-wî-hu.
10	Pa-nats.	Tăt-hûn.	Pá-naks.

	Hoh.	Makah.	Kwîl-lî-ut.
1	Lîk <sup>c</sup> .	Tsark wark.	Watch <sup>c</sup> .
2	Klă-u.	Atl or ūtl.	Klă-hu.
3	Kwail.	Wi.	Kwā l.
4	Bái-yas.	Boh.	Bái-ěs.
5	Tá-sl.	Shút-che.	Tahs.
6	Chi-tlăs.	Che-patl.	Chît-láhs.
7	Kla-wak-tsîs.	Atl-po.	Klă-wûk-ět-ses.
8	Kla-wě-tûtl.	A-tlěs-sûb.	Kla-ût-ûl.
9	Wetl-lûtl.	Sa-kwas-sûb.	Walt-ûl.
10	Chetl-tat.	Klûh.	Eks-chi-tûl.

	Kwîl-lî-ut.*	Klallam.	Cowichan.
1	Welt.	Nât-sa.	Nât-sûs.
2	Klă-we.	Chěs-sa.	I-sé-lî.
3	Kwá-lî.	Klé-hu.	Kle-hwûs.
4	Ma-es.	Nos.	Hûs-si-nûs.
5	Stăs.	Tl-káchs.	Tû-káts-ûs.
6	Chîl-ăs.	Tû-hûng.	Tû-hûm-mûs.
7	Kla-ók-us-ěs.	Tsoks.	Tsáks-ûs.
8	Klau-ûtl.	Tats.	Táts-ûs.
9	Wetl-tatl.	Tû'k-ho.	Tó-o-hwûs.
10	Kû-shetl.	Ó-pen.	O-pans.

\* Given by another informant, and I presume fully as correct as the former one.

	Summi.	Skagit.	Chemakum.
1	Nût-sa.	Du-cho.	Kwetl.
2	Chës.	Sá-li.	Klak-we.
3	Kli-hu.	Kli-hu.	Kwáil-li.
4	Ngas.	Bos.	Me-és.
5	Tl-kach-es.	Si-läts.	Chá-a.
6	T-hüng.	I-läts.	Tsít-las.
7	Tsá-kwüs.	Tsoks.	Tskol-kwünt.
8	Tats.	Tû-há-chí.	Kwai-kwunt.
9	Tûk-hu.	Hwûl.	Kwelts-hail.
10	A-pën.	O-lope.	Che-ta.

These languages are arranged in about the order in which the tribes speaking them live. In the Twana *schûch-há-chí*, and in the Nisqually *ska sûk-a-chí* means *hand*, hence we have from the same root, for *six* *i-a pá-chí* in the Twana, and *dzil-á-chí* in Nisqually, and a word for *six* of similar derivation may be found in the Snohomish, Skagit, and Kwinaielt; *Tukachi*, *eight*, from the same root, is found in Twana, Nisqually, Snohomish, and Skagit; *kl-tats* is the Klallam word for *hand*, and *tats* for *eight*, and this is found in the Cowichan of British Columbia and *Sûm-mí*, *hul-kwunt* is the Chemakum word for *fingers*, and it is seen as the origin of their words for *seven* and *eight*.

*Sa-li*, *two*, runs with a little variation through the Twana, Nisqually, Snohomish, Chehalis, Kwinaielt, Cowichan, and Skagit, and an examination of vol. 1, Contributions to American Ethnology, pp. 262 and 280, shows that a similar sound is in the Shooswaap, Okinaken, Shwoyelpi, Skoyelpi, Spokane, Kullispelm, Cœur D'Alene, Flathead, Tait, and Kuwalitsk. The Hob, Kwilliut, and Chemakum would fall into a separate class in regard to this word.

*Kle-hu-for*, *three*, slightly varied, is in the Nisqually, Snohomish, Klallam, Cowichan, Summi, and Skagit, while in Major Powell's work, quoted above, the Tait and Kuwalitsk agree with them. In this word the Hob, Kwil-li-ut, and Chemakum are again similar. The Chehalis and Kwinaielt also agree with one another, and in Major Powell's work the Shiwapmukh, Shooswaap, Nikutemukh, Okinaken, Wa ky-na-kaine, Shwoyelpia, Skotyelpi, Spokane, Piskwans, Kalispelm, Kulluspelm, Cœur D'Alene, Flathead, Silowab, and Ko-mookhs are similar.

The word for *four*, however, in slightly varied forms, easily traced, combines more of the languages given than any other numeral; *baies*, *bu-sus*, *bos*, *boh*, *nos*, *mos*, *me-es*, and similar variations are seen in all but the Chinook. It is the only numeral which connects the Makah with the others, and it shows relationship in all of the tongues, adding the Belhoota above, quoted from Major Powell's work, with the exception of the Silowab, Tait, and Kuwalitsk; in all, fifteen out of the eighteen dialects there given.

The Chinook is connected with the Chehalis only by the word for *six*. Singularly, the words for *one* and *ten* vary more than most of the others.

There had been considerable discussion as to whether words which sound alike show a similarity of origin in the tribes speaking them; but Prof. W. D. Whitney says that numerals and words indicating relationship are of more value as evidence on this point than any others. A further comparison of the four languages which accompany this shows that the Twana and Nisqually agree in many points, and the Klallam is similar to them in some, but the Chemakum, except in a few instances, is different from all the others, and these instances are such that the words may have been adopted from the Klallam, their neighbors. Dr. Gibbs\* is doubtful whether the Chemakums ought to be included in the Selish family or not. There is no doubt but they are connected with the Hohs and Kwilliuts, judging from the numerals and their traditions.† Dr. Gibbs is also of this opinion.

In this connection I would say that a comparison of the manners and customs of all the above-named tribes, as far as I have been able to learn them, show that they are much the same, varying only as their different environments compel them.

Whether or not similarity of customs shows a similarity of origin seems to be an open question. If any customs do, it is to my mind their religious rites, for experience and observation prove that they are less likely to change these than any other. In customs there is little difference among these tribes, the more northern Indians being a little more savage.

The Twana language has another form of numerals for counting money, stones, and small round things, which differs from the form given mainly in adding to it *lis*, *elis*, *alis*, or *ta lis* as a final termination. The Skwaksin a second series, used mostly for counting money, which is made by adding *els*. The Klallam has also a second form, used in the same way as the Twana and formed by annexing *ût-hu* or *aiût-hu*; and also a third form for counting animals, which annexes to the original *eks*, *ûks*, or *e-ûks*. In counting large numbers they cut notches on sticks to assist their memories. I am not aware that any of them knew anything about multiplication before the whites came, except by repeated additions.

*Time.*—The year was divided into thirteen moons, for each of which they had names, but I have not been able to learn that they had any names for particular days. The day-time was divided into dawn, sunrise, forenoon, noon, afternoon, sunset, and dusk, and the night had only the division of midnight. The present names of the days of the week have been adopted since the whites came among the Twanas. They signify holy day, one day past, two days past, etc.

*Length.*—They had four standards of measurement of length: (1) from end to end of the middle finger outstretched; (2) from the shoulder to the end of the corresponding hand, arm extended; (3) from the shoulder

\* Vol. 1 Contributions to American Ethnology, pp. 159-177.

† See Swan's Indians of Cape Flattery, p. 57.

to the end of the opposite hand, arm extended, and (4) the fathom. In travelling the standard was the distance which a person could travel in one day.

I do not know that land was measured, but in all square measure the above linear measures were used.

*Quantity.*—In measuring articles in bulk their baskets were used, but I know of no basket of standard size being used. A person making a bargain for a certain number of basketfuls would have to see the basket.

*Currency.*—The dentalia shell and the abalone shell, or parts of it, were the nearest thing to money which they had, the former being the most valuable. A species of olivella shell, found in Klallam waters, was sometimes brought to the Twanas, by whom it was used partly for money. Slaves, skins, and blankets were also used for a similar purpose, or rather for barter, but I have been unable to learn what value they put upon them or on the shells, as their values have changed greatly since the whites came. The value of the dentalia shell depended on the size as well as number, a long one being much more valuable than a short one.

#### WRITING.

They had no system of writing previous to the coming of the whites. Since that time a small vocabulary of the Klallam language, by G. Gibbs, has been published as No. 11 of Shea's Library of American Linguistics; another, of the Nisqually language, by the same author, may be found in Major Powell's Contributions to North American Ethnology, vol. I. A number of vocabularies of the Chinook jargon have been published, a list of which is given in Gibbs's Dictionary of Chinook Jargon, published by the Smithsonian Institution.\* A small Chinook hymn book has been published in connection with the mission of the American Missionary Association at this reservation, and about two hundred words of the Twana language are published in Eells on the Twana Indians, p. 93. Otherwise I know of no writings or publications in any of the languages used among these tribes.

#### GAMES AND PASTIMES.

*Gambling.*—This is very common, there being but few who do not engage in it. There are also professional gamblers, who, like the whites, generally visit large gatherings, especially potlatches, to ply their trade. Among the women it is not so common.

There are three native modes:

(1) With one or two bones. This is played mostly by young men and boys, but sometimes a large game is played by experienced gamblers. The players sit in two rows about 6 feet apart and facing each

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\* Smithsonian Miscellaneous Collections, vol. VII.



other with 'a long pole in front of each. There are from one to six played on each side, but rarely more. Then one person takes one or both of these bones and rapidly changes them from one hand to the other. One person on the opposite side guesses in which hand it is, or if both bones are used he guesses in which hand a certain marked one is. If he guesses aright he wins, and he or some one on his side plays next; but if not, he loses, and the other side continues to play. While one man is playing the rest of his party beat with a small stick upon the pole in front of them, and keep up a continuous sing-song noise in regular time. The sums bet on this game are generally small, say from 50 cents to \$1.50, but sometimes the stakes are much larger.

Some grow so expert at this game that even if the guess of the opponent is right the player can afterward change the bone to the other hand without its being detected.

The tally is usually kept by two of the players, one for each side, with sticks 8 or 10 inches long, sharpened at one end and stuck in the ground. These sticks are moved according to the success of either party. A modified form of this game is played by using two larger bones or pieces of wood. One of these is marked in some way, either with a string tied around the middle of it, a carved circle, or if it be of wood the bark may be removed except in the middle, where a zone is left. When the small bones are used, it is optional whether one or two be employed, but when they play with the larger ones it is necessary that both be used, for if the player has but one it would plainly be seen in which hand it was.

(2) With round disks. This is the men's game, as a general thing, but sometimes all engage in it. There are ten of these disks in a set. All but one have a white or black and white rim. Five of them are kept under one hand of the player on a mat, and five underneath the other hand, covered with cedar bark, beaten fine. After being shuffled round and round for a short time, one of the opposite party guesses under which hand the disk with the black rim is. He tells this without a word, but with a peculiar motion of one hand. If he guesses right, he wins and plays next; but if his conjecture is incorrect, he loses, and the other side continues to play. The two rows of players are 10 or 12 feet apart. Generally they have six or more sets of these blocks, so that if, as they suppose, luck does not attend one set they can try another. These different sets are marked on the edges to distinguish them from other sets. Another way of distinguishing them is by having them of slightly different sizes. They are made very smooth of hard wood, sand-papered, and then by use are worn still smoother. In this game they keep tally with a number of sticks, used as checks, about 3 inches long. The number of these varies according to the amount bet, twelve of them being used, it is said, when \$20 is wagered. I have never seen more than forty used. They begin with an equal number of checks for each party, and then each side tries to win all,

one being transferred to the winner each time the game is won. If there is a large number used, and fortune favors each party nearly alike, it takes a long time, sometimes three or four days, to finish a game. This game is sometimes played by only two persons, but usually there are many engaged in it. In the latter case, when one player becomes tired, or thinks he is in bad luck, another takes his place.

Another form of this game is called the tamanous game. A large number of people, who have a tamanous, including the women, take part in it, but the men only shuffle the disks. The difference between this form of the disk game and the other form consists in the tamanous. While one man plays the other members of his party beat a drum, clap their hands, and sing, each one, I believe, singing his or her own tamanous song to invoke the aid of his special guardian spirit. I was lately present at one of these games where forty tally blocks or cheeks were used, and which lasted for four days, when all agreed to stop, neither party having won the game. Very seldom do they play for mere fun. There is generally a small stake, and sometimes from \$100 to \$200 is bet.

The Indians say that they now stake less money and spend less time in gaming than formerly. It is said that in former years as much as a thousand dollars was sometimes staked and that the players became so infatuated as to bet everything they had, even to the clothes on their backs. At present they seldom gamble except on rainy days, or when they have little else to do.

There is no drinking in connection with it. Outside parties sometimes bet on the game as white people do.

There is a tradition that when Dokibatt "came a long time ago he told them to give up all their bad habits and things, these among others; that he took the disks and threw them into the water, but that they came back. He then threw them into the fire, but they came out. He threw them away as far as he could, but they returned, and so he threw them away five times, and every time they came back, after which he told the people that they might use them for fun or sport."

(3) The woman's game. This is played with implements made of beaver or muskrat teeth. It is played much after the manner of dice. There are two pairs of them. Generally two persons play, one on each side, but sometimes there are two or three on each side. The teeth are taken quickly in one hand and thrown down on a blanket. One has a string around the middle. If this one is down and all the rest up, or up and all the rest down, it counts four; if all are up or down it counts two. If one pair is up and the other down it counts one, but if one pair is up or down and the other divided (unless it be as above when it counts four), then it counts nothing. Thirty is a game, but they generally play three games and bet more or less money, dresses, or other things. They sometimes learn very expertly to throw the one with the string on it differently from the others by arranging them in the hand so that

they can hold this one, which they know by feeling a trifle longer than the others. They often keep tally with small sticks 3 or 4 inches long and about the size of a lead-pencil. But if they can they use the bones of birds' legs of about equal size. Each one keeps tally for herself. It is seldom that I have seen this game played, as the women have so much to do they have less time at their disposal than the men. They can make mats and baskets on rainy days.

(4) In addition to this a considerable number of the men have learned to play cards on which they bet considerable amounts. This, as yet, is the only mode of civilized (?) gambling which they have learned.

#### FIELD SPORTS AND FESTIVE GAMES.

*Dancing.*—This is usually a religious performance. It is, however, sometimes practiced for mere sport, and I have seen them thus dance until exhausted by their laughing and efforts.

*Horse-racing.*—As far as I know the Klallams have none of this, but a few times during each year the Twanas engage in it. It is usually conducted after the manner of the whites as far as they can do so.

*Shooting.*—A field sport which is now entirely out of date was the shooting of arrows, the object being to see who could shoot the farthest, and large bets were made. The winning arrow would sell for a large price.

*Children's plays.*—Indian children, like white children, have their own special plays, and also imitate the ways of their superiors. Among the former are ball, shuttle cock, shinny, and a native game in which there are two parties. One side holds some article, while a person from the other side advances to get it. The members of first side say all the funny things they can, and the opposite can not have the article unless their representative can get it without laughing.

In games of imitation they go through all the motions of gambling and tamanous, and these seem to be the principal ways in which they mock the older Indians.

In imitating whites they sometimes have several post-offices a short distance from each other, with as many postmasters, and a mail carrier who carries bits of paper from one to the other, or they will hold a council in remembrance of the time when some distinguished person from Washington has been here, when they will make speeches, have an interpreter, and all things in regular order. Again it will occasionally be a church, while they go through with the services, or a court with judge, jury, lawyers, witnesses, and a criminal. An odd occurrence took place at one of these mock courts some time ago which happened to be overheard by their teacher. A boy was on trial for drunkenness. When the proper time came the criminal arose and said substantially as follows: "Gentlemen, I am a poor man and not able to employ a lawyer, so I must plead my own case. The court has been



slightly mistaken about the case. I am a white man ; my name is Captain Chase (a white man living near the reservation). I came to church on Sunday. The minister did not know me ; as I was well dressed he thought I was a good man, and might have something to say, hence he asked me to speak. I knew I was not a suitable man to address the congregation, but I could not well refuse. So I rose and went to the platform, but I had some tobacco in my mouth. I tried quietly to take it out and throw it down without being seen, but the Indians noticed it, and thought a minister should not chew tobacco, and beside I did stagger a little. These are the reasons I am on trial here."

#### MUSIC.

Music among these Indians consists more of noise than melody. As a rule the Klallams are far more musical than the Twanas. The women sometimes sing alone when at work, at funerals, and when tending the children ; but in nearly all their gambling, war, boat, and religious songs the men take the lead. All persons sing the same melody, but sometimes the pitch varies considerably with different persons.

Their instruments are also intended more for rhythm than anything else. Indeed, no single one can vary the tone, the only modifications being loud and soft. They are used chiefly in their religious performances. They consist of the drum, deer-hoof rattles, scallop-shell rattles, and hollow rattles made from wood. Those who have no instruments pound with small sticks on larger ones, and clap their hands.

*Songs.*—These consist of work, patriotic, and boat songs, and songs for gambling and the nursery, for love and war, for funeral and religious ceremonies. I have known of instruments being used only with those for war and gambling, the boat songs, and religious songs, and in all of these the aid of their spirits or tamanous was invoked.

When gambling the singing is universal in the first method described, and is accompanied by the pounding on large sticks with smaller ones, different songs being sung by opposing parties. The words have no meaning. When gambling in the second method there is usually no singing unless it becomes a tamanous game, when a drum, one for each party, is brought in, and there is pounding on sticks and clapping of hands and singing. In this singing I understand that each one is invoking the aid of his or her tamanous, so as to win the game. I was present at such game not long since, and when in the house the singing was a confused medley on different keys and I could catch nothing of it, but when I was a few hundred yards away the sounds had mainly blended into song.

*Drums.*—These with the Twanas have a square rectangular head, the sides of which vary in length from 1 to 2 feet or a little more. They are made of deer-skin stretched over a wooden frame. Each one has only one head, and on the reverse side two leather thongs or straps are crossed at right angles, so as to form a handle. The drum is held with



one hand and the drum-stick in the other. They are only from 3 to 6 inches deep, but vary in tone according to size. The Klallams use the same kind of drums, and also have another, which is similar in all respects except that the head is round instead of rectangular.

*Rattles*.—One variety of rattle is made of deer-hoofs, sometimes in large bunches. These bunches are held in the hand or fastened to the waist while dancing. The Klallams sometimes also use rattles made of the scallop-shells which are found in their waters. A hole is made near the hinge of each shell, and a number of them are strung on a stick about the size of a lead-pencil, which is bent in a circular form and serves for a handle. These are shaken edge downwards. If shaken side downwards they are likely to be broken, in which case the person holding them will, according to their belief, die soon.

It has been found impracticable to translate American hymns into Chinook or to compose hymns in this language which will rhyme. The chief peculiarity which I have noticed in making hymns in this language is that a large proportion of the words are of two syllables, and a large majority of these have the accent on the second syllable, which renders it almost impossible to compose any hymns in long, common, or short meters.

#### ART.

There is no special class of artists among them as there is among the tribes to the north in British Columbia, still they make considerable work that is quite artistic on baskets, cloth, leather, wood, etc.

Their work as a general thing does not equal that of more northern tribes, but is fully equal to that of the tribes east and south. All the figures on baskets are woven in with colored grass.

#### LANGUAGE AND LITERATURE.

Six languages are in use by these Indians to a greater or less degree. The Twana is spoken by those who originally constituted the tribe. The Skwaksin dialect of the Nisqually language is employed by a number who have become incorporated into the Twana tribe and who now constitute about one sixth of it. It is understood also by nearly all of the original Twanas, and is used besides by a large number of the tribes on the Sound as a means of intercommunication.

The Chemakum is used partly by a few members of that tribe. The Klallam is used by all the members of the Klallam tribe, and dialects of the language extend into British Columbia.

The Chinook jargon has been ably compiled by Hon. G. Gibbs. I know of but three words in this locality of Indian origin which are not in that dictionary. (1) *Sā-by*, a long time, found in Swan's vocabulary; (2) *Stó-blo*, the north wind, from the Nisqually *stob-la*; (3) *Whilom*, a thread or rope, which is of Klallam origin. Out of about 800 words and phrases which answer for words given by him, only about 470 are used here, which shows how the same language will vary in different localities.

## MYTHS.

*Thunder and lightning.*—The general belief has been that these are caused by a great bird flapping its wings, and some point to trees that have been struck by lightning and say that the bird touched these trees and hence they were torn to pieces. Some say they have seen the bird, but others do not believe this. A fable by the Indians says that the Doswailopsh mountain had two wives: Mount Ranier was one, and a mountain near Hood's Canal was the other; Mount Ranier and this mountain quarrelled and Mount Ranier moved away, and now they always fight by thunder and lightning.

*The sun.*—In addition to those traditions given in "Eells on the Twanas," I give the following from the Klallams:

"A long time ago there was only one woman in the world, but no man. She made a man of gum and set him up and wished him to become alive and to be her husband. She went to sleep and life came to him. Being of gum, he was very sensitive to the heat of the sun, which was much hotter then than now. He worked when it was cool and rested in the shade when it was hot. He had some children. One day he went fishing and told his wife to look out for him if it became hot; but she went to sleep and did not do so, and the heat grew intense and melted him, and he died. His sons were very angry at the sun for this; one of them made a bow and very many arrows. He shot them up towards the sun and they formed a chain or rope on which the boys ascended, and found a prairie land. They asked the geese, who could then talk, 'Where is the man who killed my father?' and the geese pointed in one direction and said 'Yonder.' The boys went in the direction indicated, and came to a house where two blind women lived, and they sat down. As one woman gave some food to her companion one of the boys took it. 'Have you received your food?' said the first woman to the other. The latter replied 'No,' and both wondered what had become of it. Soon one of the boys said he had taken it and asked 'Where is the man who killed my father?' The woman replied, 'Farther on,' and gave them a very small basket, in which were six salmon berries. The boys went on and soon found some swallows which could talk, and again they asked, 'Where is the man who killed my father?' The swallows said 'In yonder house.' The pair went to the house and found an old man piling pitch wood on a very hot fire, so hot it nearly roasted the boys, and this was what made it hot on the earth. They gave the old man the six salmon berries, which became very many and swelled within him and killed him. The fire then went down somewhat, and it has not been so hot on the earth since."

## FABLES OF THE TWANAS.

*The pheasant and the raven.*—The raven had a trap and caught very many fishes, but would not give any to the pheasant. At last the pheasant went to hunt deer. While he was on his way a deer met

him, driven by a man. The pheasant killed it, and when he was skinning it the man stood watching him and said, "Well, pheasant, you can shoot straight;" but the pheasant thought it was not so. So, when the man saw that the pheasant was not proud, he said that the latter would be able to carry the deer nearly home, only when he should almost reach his house that it would become very heavy. And so it was; for when he was almost home it became so heavy that he could not carry it. He laid it down, and his wife came and helped him. When the raven heard that the pheasant had killed a deer he sent his sons to carry some fishes to the pheasant, so that he might receive some meat in return; but when they were going into the pheasant's house the pheasant drove them out. Then the raven told his children to fight with the children of the pheasant, and they had a battle. The raven's children threw fishes at the pheasant's children, who, in return, threw the grease of the deer at the raven's children. The raven sat between the two armies, and when the little pheasants threw any grease the raven caught it and ate it. After a time the raven went to hunt deer. While he was travelling he met and shot a deer, driven by the same man whom the pheasant had met. While he was skinning it the man, acting as if he was surprised, said, "The raven can shoot straight." The raven was proud, and said, "I can shoot straight, because I am a raven." When he was about to carry the deer home the man said that when he should nearly reach his house it would turn into something else. So, when the raven had almost got home, he dropped his game and went and told his wife where to find it. She went to the place where he had left the deer, but when she arrived she found it had all turned to rotten wood.

*A woman and her husband.*—At one time there was a woman living at her father's house, and after awhile a man came by night and took her for his wife, but soon afterwards he deserted her. After a time she took some of her father's slaves and went to the other side of the water to hunt for the man, but was unable to find him. So she started for home, but after having gone some distance she looked down on the bottom of the canoe and saw a man smiling at her. She knew it was her husband; he pulled her down, and the slaves saw her no more. Some time afterward she made a visit to her parents. At a second visit a child was born to her. On a third visit her face was covered with some kind of moss. During her second visit her parents wished to deceive the man, hence they took a slave with a face exactly like that of the married woman and started to carry her to the man, but a sea-gull cried out and said it was not the right woman, so they took the true wife and restored her to her husband. This man killed a great many fishes and sent them to his father-in-law. After a time the woman died and there was afterwards heard a voice crying, which was the woman's voice. When this woman's tribe go off to sea they always capsize. (Some Indians believe this to be true.)



*A Colcine Indian and a wolf.*—One day a woman espied a wolf swimming across Colcine Bay. She told her husband, who, wishing to have the skin, went to kill the wolf, but his wife begged him not to do so. The man rowed out to the wolf and patted him on the head with his paddle. The wolf looked at him and threw his ears back as if he would beg for his life. At last they both reached the shore, when the wolf did not run away from the man, but stood on the shore and looked at him with his ears back. The man, then wishing to deceive the wolf said, "I do not want to kill you but was afraid you might drown, so I came to help you across. Now, for a reward, I ask this: You must drive as many deer to me as you can." So the wolf went into the woods and drove home deer until the man's house was filled with meat. Every time the wolf came home he would drive home a deer.

*The taming of two young wolves.*—There was once a great hunter (who the narrator said was his father's brother), at one time when out hunting who found two young wolves which he thought he might tame, so that they would assist him in hunting deer. He brought them home, and when they were partly grown he took them out. While they were going along they found the mother wolf, and as the man wished the cubs to grow fast he took her too. After that this hunter never failed to kill deer. "This," said the narrator, "only shows how animals can understand and act well to those who are kind to them."

Although there is something fabulous in the former of these last two stories, if not in both, they may show how the Indian dogs were first obtained by domesticating wolves.

#### DOMESTIC LIFE.

*Marriage.*—Among these Indians marriage by purchase was formerly the universal custom, and even now they are loath to abandon it. It is customary for a man to seek for a wife within a certain circle of his relatives. I knew a widower of perhaps forty-five or fifty years who sought to marry a woman properly related, but being refused he was at liberty to seek for one wherever he wished. He found a girl not over fifteen years of age among the Skwaksins, not as old as one of his daughters, and married her. Her father consented to the marriage and she, although reluctant, was obliged to submit. It is not often that a marriage takes place where either party strongly objects, but oftentimes the relations consult the parties to some extent, doing at the same time most of the courting for them.

Usually a man's relatives help him to pay for his wife from \$100 to \$400 worth of money, blankets, guns, horses, and such articles, which are given with many speeches and much ceremony, something being said as each article is presented, the whole occupying one or two days. Occasionally the parties live together for some time, even a year, before this formal ceremony takes place.

Marriages with other tribes are common. The Twanas are intermar-



ried with the Chehalis, Skwaksin, Nisqually, Puyallup, Snohomish, Port Madison, Lummi, Chemakum, and Klallam Indians, and the Klallams with the Twana, Snokomish, Chemakum, Makah, Kwilleut, Nittinat, Cowichan, Sook, Victoria, and Summi Indians. It is very common when an Indian begins to speak of his ancestry to find that there is the blood of some other tribe in his veins, through either the parents or grandparents. The children belong to the tribe of the father usually, and the mother is adopted into the same tribe, though there are occasional exceptions to this rule. At one time I saw a Klallam man who had just married a Nittinat woman, and when they were married the man could talk the Klallam and Chinook languages but not the Nittinat, and the woman could not speak either Chinook or Klallam. The Twanas, Klallams, and Chemakums are also intermarried with the whites. Very few of either tribe have more than one wife each, the custom of the whites and the law of the agent preventing new cases of polygamy, although those who formerly had more than one wife have not been compelled to give them up.

*Children and their cradles.*—A few have adopted cradles on rockers, similar to the poorer ones of the whites, but the old way of bedding infants is by far the most common. For this they take a board a little longer and a little wider than the child, or hollow out a thick cedar board, about the same size, to the depth of an inch. In either case they place on this board beaten cedar bark, on which they lay the child, who is then covered with cloth and tied to the board by strings which pass through the holes in it. The hollowed form is more common with the Klallams, and the other with the Twanas. A cap of cedar bark, usually of Makah make, is sometimes used by the Klallams as a cover to protect the babies from the smoke.

The practice of flattening the head, which was formerly common, is now ceasing. It has so often been described that I can say nothing new about it. Some who have had the head flattened in infancy seem to make as good scholars as those who have not been thus treated. One Indian attributes much headache to this cause.

*Naming children.*—Usually they are not named at as early an age as with the whites, but when one, two, or three years old. Formerly, when the name was given, a feast was made and presents given to the guests. An Indian may change his name once or several times during his life; sometimes he does so when one of the same name dies, as it is not good etiquette to pronounce the name of the recently dead. Two or three years after death the name of the deceased may be mentioned; and with the Klallams, at least, a person may take the name of his departed father, grandfather, or other direct paternal ancestor. Often when this is done, the person thus changing the name makes a feast and gives presents. Nearly all the men, women, and children have "Boston" names which they have received in various ways. Some of these are a combination of Indian and American names and constructed utterly regardless of taste.

## SOCIAL LIFE AND CUSTOMS.

*Eating.*—Generally they eat three times a day. At a visit of seventy-five Twanas to the Klallams of Port Gamble, they feasted three times during one night, closing at 2 or 3 o'clock in the morning. The feasting was interspersed with gambling, conversation, and the giving of presents. In December, 1878, the Dungeness Indians and some Indians from Port Discovery were invited to a feast at Sequin, which lasted two nights. They feasted first at one house, where they tamanoosed in a manner similar to that described as occurring at the same place two years previous, and made presents; after this they went to another house and did the same, then they repeated the same performances at a third house, and closed about 2 in the morning. On the next night they went through the same acts and ceremonies; fourteen boxes of biscuit and a barrel of sugar were consumed or carried away by about one hundred and twenty-five persons, men, women, and children; quite an amount was carried away by them, this being customary. Very often their feasts occur in the day-time, and consist of only one meal if the guests are few. There is more or less feasting at all their large gatherings, including those for religious purposes.

*Potlatches.*—A peculiar custom with the Indians in this region is the potlatch, which takes its name from the Chinook word, meaning to give, as the most prominent feature in it is the distribution of gifts. I have never heard of this custom existing farther south than the Columbia River or farther east than the Cascade Mountains, but on the west it extends to the Pacific Ocean, and on the north into Alaska, a rich chief there having in 1877 made one at which four thousand Indians are said to have been present. It seems to be chiefly confined to those Indians who live near the salt water, as it would be difficult for those who have to travel on horseback to carry the amount of articles which they have need of on such occasions. How old the custom is no one seems to know. A part of the ruins of a very old potlatch house were found while digging below Port Gamble. The origin of the custom is supposed to be as follows: A chief wishing to gain the favor of his people gathered them together and made presents to them; after a time this was repeated and people of other tribes were invited on account of friendship, and the compliment was returned; chiefs or other persons who wished to become prominent followed the example until the custom grew to its present proportions. Now nearly all the surrounding tribes are invited and almost every individual, both man and woman, feels bound once, at least, to have a share in giving a potlatch; the potlatches now become so expensive that seldom does a single person feel able to make one, hence many combine their resources for this purpose.

Often a person will save everything possible for years in order to give it away on such occasions, and when one feast is done they will begin

to save for another. In the distribution all do not receive equal amounts, but special friends, the young and strong and those who are planning to make a potlatch, generally receive the most in the hope that they may return the compliment at some future time, but the old and those not likely to give such an entertainment receive but little, it being a poor investment to give to such persons. Potlatches are the greatest festivals of these Indians.

Tamanous ceremony and social intercourse, including feasting and the distribution of presents, are the prominent features of the occasion, while as side shows they have courting and gambling, the latter being very prominent.

These feasts do not occur with any regularity, and there are many old persons who have not taken part in giving more than one potlatch in their lives. About the year 1868 one was given by a number of Twanas. In 1876 another was given to a totally different set of the same tribe, and in 1878 another was given by them in which only one man participated who was present at one ten years previously. Others of those engaged in 1868 had intended to take part, but some of their children having died they gave way so much at their funerals that they had nothing left to share in the potlatch.

I was present at a potlatch given by several Twanas on the Skokomish reservation in October, 1876. For many years they had been preparing for it. Old women went in rags, while filling trunks with calico to give away at this time. Of these boxes of dry goods some had been deposited in my hands for more than a year. In the winter of 1874-'75 they began the erection of the house, working only a day or two at it now and then; but in the summer following the leader of the affair died and nothing more was done until the spring of 1876, when others took hold of it and half finished it. They set the time for the potlatch in August, but because they were not ready deferred it for one month and then for another. Two or three weeks previous to the event they again went to work at the house and finished it. It was by no means large enough for all who were present, but mat houses, tents, and other temporary shelters were put up around it by various persons. About the 14th of October they sent runners to the various surrounding tribes and on the 29th the first installment arrived, consisting of about a hundred Chehalis Indians. They came in wagons and on horseback to within about 4 miles of the house—as near as they could because of water. Here they were met by a leader of the potlatch, and after considerable speech-making they camped for the night. The next day the Twanas sent six large canoes to take them to the house. At noon they rowed past the agency, 1 mile from camp, abreast, singing a solo and chorus, accompanied by drumming on two drums and pounding on canoes. After passing the agency they broke line and so went on for a mile or more until they came in sight of the potlatch house, when they again formed abreast and rowed to the house in alignment



with their music. At landing there was more ceremony, for the visitors had brought many presents. Each present was held by the donor while he made a speech, after which he gave it to a Twana, who replied to the speech, when the gift was handed to the one for whom it was intended.

These presents consisted of calico, blankets, two beeves, dried meat, and money (\$60 having been counted as coming from one canoe), and seemed to be given to the prominent Twanas. The Chehalis then landed and went to one part of the house assigned them, where they took lodgings. The whole performance occupied three hours and was longer than that of any other tribe. Two days afterwards the Klallams came in sight and when about 3 miles away a member of the Twanas went into a canoe to meet them and learn their wishes about landing, this being the common custom.

They learned however that while the Klallams were coming, a child had been killed by the caving of a bank. The child had some relations among the Twanas, who immediately began a mourning. The Klallams stopped on the beach at a Twana burying-ground, a mile from the potlatch house, where they left the corpse in a box on a log, covered with mats and blankets, as they intended to take it home with them on their return. Here a canoe-load of the Twana relations of the child came, and there was mourning again, but it did not last very long, and after it was done the Klallams entered their canoes, went a half mile farther and camped, most of the afternoon having been thus consumed. The next morning they all came abreast close to the shore near the house in about fifteen canoes, singing and dancing and pounding on drums, canoes, and boards. It was intended that this should be the grand reception, as the Klallams are about the best musicians and performers on the Sound, but a strong wind arose so that it was hardly possible for the canoes to remain long near the water's edge. While they were in front of the house they sung solos and choruses, some of them holding guns and paddles in their hands and jumping up and down. One had a rattle. Some had on cedar-bark bands, which had eagles' and hawks' feathers and wings in them. The faces of the majority were painted—many black, a few red. After a few minutes of this performance the Twanas replied to them from the beach in a somewhat similar way. Some of the faces of the Twanas were blackened a little, but not as much as those of the Klallams, and they had neither rattles, headbands, guns, or paddles.

Thus, the salutation and reply were kept up for about half an hour, when the Klallams landed with no further ceremony and went to their quarters in the house.

The ceremonies of landing were a slight part of the black tamanous and the only performance of the kind during the potlatch, and this was the only reception in which the Twanas replied to the songs of their guests.



Other tribes kept coming every day or two for two weeks, and the reception was much like that already described. Generally, they were met 2 or 3 miles before reaching their destination by some of the Twanas, who learned their wishes about landing and directed preparations to be made accordingly, and commonly they brought some presents of cloth, food, and money and danced and sung, but a few landed without any ceremony. When they had all arrived it was estimated that there were from a thousand to twelve hundred present, comprising, besides those already mentioned, Skwaksins, Nisqually, and Port Madison Indians and a few from the Snohomish, Lummi, and Puyallup reservations.

They who lived farthest off had come a distance of about 150 or 175 miles, but these had relations by marriage among the givers of the potlatch. Generally the evenings were occupied with dancing of some kind, either serious or comic. Frequently one whole evening was allotted to the dancing of one tribe. These dances were accompanied with drumming, singing, and clapping of hands. In dancing they jumped up and down, sometimes joining hands in a circle, and sometimes each one dancing singly, jumping the whole length of the house. At times the men alone danced, and again the women joined them, generally having a part of the circle to themselves. Once almost, all joined in the dance, having green branches in their hands. On this occasion they danced at one time without progression, and at another time they moved around from one end of the house to the other. The Klallams gave one dance, difficult to describe, in which men only participated. In this a leader, painted, with eagle wings and feathers dangling from his head, and arrayed in a long blanket, played very curious antics with contortions of his neck, hands, and entire body, while the rest stood near him, jumping up and down to their music, and afterwards all dressed in striped shawls and blankets, danced the whole length of the floor with many absurd maneuvers. I think this was a war dance. One dance was said to be in memory of a deceased child, after which presents were made by friends of the child to some of the Twanas. Thus almost every evening was occupied from the time of the arrival of the first until the close of the affair, a period of three weeks.

There was more or less gambling during the day-time and occasionally at night, but few, comparatively, being engaged in it at any one time. Sometimes the gambling was accompanied by music. Once it was said there was a bet on a game of \$200 in money, together with several horses and guns, but the parties played until 6 o'clock in the morning and then stopped, neither party winning.

Generally they gambled with disks, but sometimes with the pairs of bones or cards already described. There are said to be professional gamblers among them who visit such gatherings, without an invitation, in order to ply their avocation.

There was much of tamanous in connection with the dancing, and one evening was wholly occupied in a tamanous over a sick woman and child. There was some of this in the day-time also.

The Twanas, from their own resources or from the presents which they received, were expected to feed their guests most of the time. Sometimes they gave the food to the visitors, who cooked it for themselves, but once or twice a day commonly they both cooked and distributed the food. When this was done, they seated their guests in the middle of the house in two rows on mats. When the meal consisted of boiled rice, wheat, or fish it was placed before them in large kettles, from which they helped themselves with their native ladles; but when it consisted of berries and crackers, bread, apples, potatoes, and dry food it was placed in troughs, made of 6-inch boards, 8 or 10 feet long and three-sided. Sometimes, when the meal was over, two persons would stand, one at each end of a long row of eaters, holding tightly before their faces a piece of calico on which all would wipe their mouths. They then arose and departed.

The potlatch or distribution of gifts took place in the day-time, two days after all had arrived. The women first gave away their things, and afterwards the men did the same. The gifts of the women were chiefly new calico, with a few dresses and a little money. Each giver gathered those to whom she wished to make presents in two rows facing each other, in the middle of the house; next she placed her trunks at one end of the rows, took out the pieces, laid them in a pile or two, counting them over, then, taking one or two things at a time, she carried one to each woman. Each piece contained, commonly, between 5 and 9 yards. Occasionally two or three women combined together and gave at the same time, if they were not very wealthy, but the richer ones gave each by herself. About thirty women thus distributed their gifts. Often several gave to the same person; though every woman present did not receive gifts, only those who were preferred. Three of the more prominent women gave away about one hundred pieces each, and I am not aware that any woman gave to more than this number of persons. If all averaged half as much, they gave away nearly 10,000 yards, and this was the best estimate I was able to make of it. This occupied about two days and a half. A day and a half was then consumed by the men, who gave money chiefly, but occasionally blankets and a few guns. The recipients were arranged much as with the women, but were all men, and the distribution was conducted in much the same style. There were ten male donors, each of whom gave, generally, from \$1 to \$2 to each of his friends, so that most of the latter received from \$2 to \$10 each; some got more, and one who was expected to make a large potlatch in a year or two received \$40. They gave on an average a little over \$300 each, and the whole sums given away amounted to about \$3,300. A few of the donors borrowed some of this money from their friends with considerable ceremony, promising to repay. One Indian who received a nice beaded cloak and some other articles put them on a fire, where they were consumed, in memory, it was stated, of a deceased child.

The distribution of gifts was the last scene, for then the visitors put their things in their canoes and left with very little ceremony as quickly as possible, and in three weeks from the first arrival the house was deserted by the visitors. It is considered by them a breach of etiquette to remain in the house any longer than absolutely necessary after the gifts are distributed. A few of the Twanas remained in the house, using it as a dwelling, for a month or two, after which it was deserted for nearly two years, and some things about it suffered to go to ruin. This whole affair occurred 3 miles from my residence. I was not able to be there all the time, but was present a few evenings and a part of nearly every day and gathered what information I could from others who were there in my absence.

Another potlatch took place at Jamestown, in Clallam County, and was given from February 2 to February 10, 1878, by a part of the Indians of that place. The house was built for a large dwelling a year or two before, the potlatch, however, being in contemplation, and was about 32 by 84 feet. It was by no means large enough to hold all of the Indians who attended, but in the village there were about a dozen dwellings, in which some of the visitors were received. The beds and seats of this potlatch house were much the same as that of the Twanas, but the shelves overhead for the storing of articles were differently arranged. Instead of being all around the house over the beds, they were along the side walls, with one shelf across the middle of the house. The two at the ends were used chiefly for storing articles belonging to the visitors, and the central one was for storing food, which included sixty sea-biscuit and a few half barrels of sugar, brought by the guests and presented to their hosts. In one corner a blanket was fastened up, evidently to make a screen for a dressing-room. I was present nearly all of the time, having been requested by the Twana and Klallam chiefs and the Indian agent to go, in order to oversee the festivities and prevent any conduct that might tend to produce a disturbance.

The invitation was received at Skokomish on the 26th of January, and on the 30th we started, and arrived at Dungeness on the evening of February 2. The morrow being Sunday, I induced them to land at once, instead of postponing it until next day as is usually their custom when reaching a potlatch place in the evening. My companions preferred that I should not be with them during the reception and hence I went ashore in a Klallam canoe which came to meet us.

About ten canoes from Sook, in British Columbia, had arrived that morning, with perhaps one hundred and twenty-five Indians; twenty-five persons from Port Discovery, the same number from Port Townsend, and forty from Sequim had arrived during the day; sixty from Port Gamble had also arrived within a day or two.

That evening was given to the Twanas, who sang and danced the black tamanous. In the dance each remained in one place, and, to keep time to the music, jumped up and down a little or bent the knees. Their



faces were also blacked in various ways. In fact, from this time for five days the faces of most of the Indians present, men, women, and children, were blacked more or less, some during the whole time. The paint was laid on in diverse patterns of stripes and spots, and some were wholly in black, others in red or black. The next day being Sunday, most of them attended divine service; but they were too much excited to give up the whole day to rest, so in the afternoon a number of the women assembled in one of the large dwelling-houses in the village, sat down on mats in two long rows, facing each other, and pounded with small sticks ( $1\frac{1}{2}$  or 2 feet long) on larger sticks and boards in front of them, and sang for some time. There was a second performance in another house afterwards by the women, in which they sang much as before, only they were accompanied with the drum, and were seated in a large circle. Within this circle two women and four girls danced. These six dancers, being graduated in size, arranged themselves accordingly, from the tallest to a child about eight years old. Their shawls were pinned behind their backs so as to cover their hands, which were extended about a foot and a half from their bodies, and they danced around a circle 8 or 10 feet in diameter. The evening was given to the Sook Indians in the potlatch house. For a time they danced in one end of the house in a manner similar to that of the Twanas the previous evening, but with more jumping, and their singing was more varied and quite wavy. After a time two of them stripped to the waist, and, with their drawers rolled above their knees, ran forward the whole length of the house, striking at everything and everybody within their reach, their arms constantly swinging around them; sometimes they went down on all fours, and, having snuffed the ground, rose again. Around the waist of each was tied a rope which extended back 6 or 8 feet, and was held by another Indian, who frequently jerked it, sometimes throwing the tied man to the ground.

Another dancer had a hideous mask on his face and a blanket on his shoulders, but his actions were not so fierce as those of the other two. He often sat down. When these were done, other Sook men came, shaking rattles, beating drums, singing, and going back and forth in the house and scattering the people who were standing around. This performance was kept up until late at night.

Monday forenoon was spent at a feast, to which men only were bidden. Beef and potatoes were cooked thus: A large number of stones were placed in a fire out of doors, and when hot the food was placed on them, covered with small dry bushes and mats, and so kept until it was cooked. At this feast the Indians did not eat in the main potlatch house, but at the residence of one who helped to give the potlatch, and who was the sole giver of this particular feast. The Indians all ate around the house on the platform made for beds, and the long troughs for food were placed in front of them on the same platform. Most of these troughs or plates were similar to those used in the Twana



potlatch already described, but some were dug out of wood, were 5 or 6 feet long, 2 or 3 inches deep, and about 10 inches wide. There was one which was dug out roughly, about 24 feet long and the same width as the others. Whatever food was not eaten was carried away, and after the feast was over crackers were given the guests on purpose to be carried off.

For napkins they used small bundles of beaten cedar bark about 2 feet long, which are very desirable, as in these feasts they eat with their hands. As soon as the meal was finished there was to be some kind of performance by the medicine men, and no other persons were allowed to remain. In the afternoon, as I returned from my dinner, I saw a masked Indian, the same I suppose that was masked the night before, and three others similar to the two half-naked men of the previous night, dancing backward and forward for a distance of about 100 yards on the beach in front of the houses. The masked dancer went through some performances not fit to be described. Their dance consisted chiefly in running around with ropes encircling them, held by others, as on the previous night. This dance continued until about 2 o'clock P. M., when they danced off into the woods, followed by forty or fifty of their friends, with the singing, etc. They all formed a large circle as they moved off, and did not return until 5 o'clock, when they reached the beach a quarter of a mile from where they left it. Some three of them, apparently tired out, were each jerked up by six men wrapped in blankets and carried into the potlatch house. One walked in supported by attendants. I have inquired frequently the meaning of this ceremony, and could get only the answer, "It is their tamanous." I infer it was an initiatory custom with the black tamanous. Some of them, I heard, were starved a part or all of the time. One young Klallam half-breed, it was said, was told that he would be obliged to go through some such initiatory ordeal at this potlatch, and he declared he would rather run away and hide until it was over, but the Port Discovery Indians took him some time before the festival, guarded him closely, and compelled him to submit. I suppose this was true, as he was not seen anywhere until the ceremony was over. While these scenes were being enacted the women met and sang in their usual way, and when I asked why they did so I was told that they were tamanousing in order to get strong minds towards the men.

Towards evening the Indians of Elkwa, Pisht, and Klallam Bay arrived, and landed with considerable ceremony, dancing, drumming, rattling, singing, and making presents. The presents were generally a blanket or a few dollars to each one making the potlatch. One man gave the head potlatches eight or ten small sticks about 3 feet long, a promise, it was said, that he would, after reaching the house, give his host \$150 in money. There were also a few more large presents given to the same man, which were kept, and returned to the givers at the close of the potlatch, so that the presenting was a mere form.

Many of them had the down of ducks on their heads and blankets. Before they reached the house a few Elkwa Indians, who had previously arrived, ran along the beach and entered the Elkwa canoes, so as to land with their own people. This was the last arrival. Some were invited from Victoria, but did not come. Those present were, as near as I could estimate: Twanas, from Shokomish, 90 miles distant, eight canoes, seventy-five persons; Sook Indians, from British Columbia, from 40 to 75 miles away, ten canoes, one hundred and twenty-five persons; Klallams, from Elkwa, Pisht, and Klallam Bay, 25 to 75 miles distant, five canoes, seventy-five persons; from Port Angeles, 20 miles distant, twenty persons; from Port Discovery, 7 miles, twenty-five persons; from Sequim, 6 miles, forty persons; from Port Townsend, 25 miles, twenty-five persons; from Port Gamble, 40 miles, five canoes, sixty persons; at Dungeness, one hundred. Total, five hundred and forty-five.

The evening was given to the Elkwas, and their performances were similar to those described. On Tuesday I was not present, but was informed that gambling and the giving away of calico were the principal features of the day.

On Wednesday forenoon the Indian who was to give the feast, Tenas Joe, made his potlatch in his own house, and in the afternoon there was a dance given by four girls, graduated in height. These were led by two old men. Some handkerchiefs and other articles were burned on a fire in memory of the wife of Tenas Joe, deceased. In the evening the Klallams danced their war dance, which was rather pretty and was said to be an imitation of the Makah dance. There were nearly twenty-five dancers, mostly men, who were dressed in American style, except that they had no shoes and wore parti-colored shawls and blankets thrown around them. One man carried an open umbrella. Their heads were bound with head-bands of cedar bark or kerchiefs, in which were long white or gray feathers generally tipped with red. Much feathery down was sprinkled over them. They had hollow wooden rattles and tails and wings of hawks or eagles in their hands. Their faces were blacked in various ways. With the music of the drum and singing they jumped around in a space 20 feet in diameter, throwing their arms wildly about, now up, now nearly to the ground, with movements quick as those of a cat in the midst of hot fire. That evening six of the principal potlatches gave me \$7.50 to pay for my board while watching over them.

About 11 o'clock A. M. the finale of the black tamanous began. First, five men came out of the potlatch house to an open space in front of it. They were stripped to the waist, with no pantaloons on, but with drawers rolled up above their knees, and with shawls thrown over their shoulders. Each wore a head-dress consisting of a band, from which hung a large number of strips of cloth of various colors, but mostly red, about an inch wide and 12 or 15 inches long. So many of these

strips hung in front that it was impossible to catch a glimpse of the face. Their legs were painted with stripes of red, and wet with water to imitate blood. They jumped around in many ways, high and low, sometimes running and clapping their hands, while the other Indians accompanied them with the usual chanting and black tamanous music. After a few moments they ran back into the house. Then about as many more came out in much the same garb as those seen on Sabbath evening and Monday afternoon, with ropes around their waists held by others. These had cut themselves slightly under their tongues and chins, so that the blood ran down their arms and breasts a little, and their faces were so black that it was impossible for me to recognize them, although well acquainted with some of them. They jumped around much as the previous set had done, and then went back to the house. Then the first set again came and performed in the same way as before, and ere they returned the second set were out again, but some of them were not held this time by the ropes. Such actions as these were kept up for nearly three quarters of an hour, when one set ran off up the beach for 200 or 300 yards, accompanied by their friends, both men and women, and soon the other set followed in a similar manner. I judged from appearances that I was not wanted, so did not go. They remained there about two hours, while I went to dinner, and the performers, it was said, were washed by the others. After this they came back. The first set were in front, surrounded by their friends, who kept up the usual noise. They ran towards the water as they advanced and then away from it a few rods, so that they moved along the beach very slowly. After them the second set came in a similar way and three women had by this time become so excited that they also danced as the men did, but in their usual dress. After them came a third company following one boy. He had on a shirt and pair of pantaloons, rolled up above his knees, and on his head a band with a very long feather standing up in it. He walked into the water knee deep, bowed his head until he dipped the tip of his feather in the water, then he walked slowly up the beach for about 2 rods, then went into the water again as before, and so advanced along the beach very slowly towards the house. This was said to represent a crane, and is called the crane tamanous. I understood that this boy, who was about fourteen years old and was a Klallam, was being initiated into this kind of tamanous. When each company came near the house each dancer was seized by two or three persons and hurried, half running and half carried, into the potlatch house. Two or three times I asked them what this was intended to teach and could only get the answer, "It is their tamanous." So I could only look on and gather most of my information in this way. As these are the rites of a secret society it is not strange that the members do not explain them to the uninitiated. After all went into the house two companies were formed, one at each end, and there was a strife to see which should conquer; but the house was



so crowded it was impossible to see what had become of the dancers who were outside. A new dance was now performed. In this a number of men, taking hold of each other's hands, formed a circle about 12 feet in diameter and ran around a pole which was set in the ground. Outside of this circle was another running in an opposite direction, and outside the second was a third going in the same direction as the first.

There was no confusion and they kept good time to the usual noises. After this they formed sides to push against one another, each endeavoring to push the other from its position. There was not room inside for any one who did not wish to be pushed, so I stepped outside. The fun continued about two minutes and ended in a hearty laugh, which closed the scene for the afternoon. In the evening all dancing was carried on in one-half of the house. A large fire was built in the center of that half. At the end of the house I saw four of the heads adorned with head-dresses of cloth strips which I had seen during the day. I suppose they belonged to the first set of dancers. Their bodies lay prone underneath the bed platform. Each one, held down by a single man, kept his head constantly moving from side to side, and one groaned most of the time. They evidently struggled to rise, and during the evening one did get up, and it required two or three men to put him down again. Most of the company were seated around the side walls. Soon one man of the company arose, took a hollow wooden rattle, said a few words, and walked around the fire, frequently makingsome motion towards the men who were held down. Having gone around the fire once or twice, he shook the rattle towards some one, whereupon ten or fifteen men jumped up, ran around, threw their arms wildly about them, bent down almost to the ground, and went through various antics; at times two or three would catch hold of each other and jump up and down together; then one or two would seize the one with the rattle with feigned violence and exertion, feigned, I suppose, because only once during the evening did I see him brought to the ground, while he seemed to make little effort to stand up. This would occupy about five minutes, during which the music ceased not, when all would return to their seats, and the leaders would lay down the rattle. Then another would take the rattle, and the performance would be repeated, and this was kept up for an hour or more. After this was done, two of those nearly naked arose and danced the whole length of the house and back again, held with the ropes around their waists as before, and accompanied by others; then they were taken out with a great shout and, as I supposed, released. This done a company of half-dozen men took one of those who had been held down and slowly carried him outside where with a whoop he was let go; after him three others were taken out and released in a similar manner, the whole act being accompanied with the usual music. That ended the black tamanous scene as far as I know. By the next day nearly all the black paint was washed from their faces, and I saw but very little more of it during the potlatch. As far as I have learned



the northern tribes on the Sound practice this black tamanous in a more savage manner than their brethren of the south, and I am told that in British Columbia it is marked by still greater severity. Friday forenoon was occupied by Dick Sooks and his father in potlatching money in the potlatch house, for the residence of the former was 5 miles away, and he was a relation of the head potlatcher. In the afternoon Port Discovery John gave sea-biscuit to the men, twenty-five to each. In the evening fifteen or twenty Klallam young men came dancing into the house where I was sitting. For a time they stood in a row and danced backward and forward the length of the house, but at last they stood at one end, dancing to the usual noises, except that of the hollow wooden rattle, for this instrument was laid aside when the black tamanous ceased. One Indian put on a shawl, took another sort of rattle made by the Clynquot Indians, and danced in front of the rest shaking his rattle, jumping up and down and around and squatting. While this was in progress a small company of Twana young men were dancing in the doorway and on the outside, mostly out of my sight, but there was evidently some rivalry between the two companies. There was considerable merriment in these dances.

Saturday forenoon, Port Discovery John, son-in-law to the principal potlatcher, gave away his money and blankets. It was the first time I had witnessed all the ceremonies connected with the donation. He first arranged all the men around the house on the bed platform, and then, with five or six friends, spent some time in counting his money. Next, twelve or fifteen women came to serve as a choir, and sat down on mats near the money. Then came four girls, arranged according to size, as before described, with faces painted completely red, hair covered with down, hands extended, as on the previous Sunday, under shawls or blankets pinned behind them, who danced the whole length of the house and back a few times, the tallest going first, led by an old man—"Old Slaze"—and followed by one still older. The choir sang, accompanied with a drum. These ceremonies occupied about fifteen minutes, after which the potlatch began. The giver told a man who acted as crier the name of the person to whom the money or article was to be given; the crier then took the gift, heralded forth the amount of the same, with the name of the receiver, and carried it to the latter. Previous to this, however, certain amounts, varying from \$20 to \$50, tied up, were given to several persons, which I was told was to pay them for certain articles brought, or was money which they had brought and was now returned to them. These things occupied all the forenoon, and in the afternoon Old Slaze gave about twenty-five sea-crackers to each man. The next day being the Sabbath, I was with them but a very short time. The ceremonies, I was told, were about as those of the preceding day. This ended the affair, and after it, all left as soon as possible.

They left about noon, but the greater part of them went only 5 or 6 miles away, as they were reduced to sea-biscuit and sugar, which was

very dry, and they wished to go where they could get clams and fish. The Twanas only remained with me until next morning, when we left.

The amounts given by the men, as near as I could learn, were as follows :

Wednesday: Money, \$1.00; one beef, \$30; one gun, \$8; total, \$138.

Thursday: Money, \$170; one canoe, \$20; twenty blankets, \$40; total, \$230.

Friday: Money, \$270; one gun, \$10; twenty-seven blankets, \$54; total, \$354.

Saturday: Money, \$430; twenty-five blankets, \$50; total, \$480.

Sunday: Money, \$420; twenty blankets, \$40; total, \$460. Total: Money, \$1,390; blankets, \$184; miscellaneous, \$68; whole amount, \$1,542.

One hundred dollars of Old Slaze's money belonged to his wife, but they combined together.

The men present received various sums, generally about \$10 each, but some received as much as \$30. Besides this, seventeen women gave to the other women calico at different times from Monday until Friday, each piece containing generally 5 yards, but varying from 4 to 9 yards. A rough estimate made the whole of this amount to 5,000 yards. There was only one case each of drunkenness and quarrelling that came to my knowledge.

During most of the time there was a large amount of gambling among the men, and some among the women, with disks and bones.

#### FUNERAL AND BURIAL CUSTOMS.

Their sepulchres, as far as I can learn, represent five different ages and have, to some extent, co-existed. There are places where skeletons and parts of them have been plowed up or still remain in the ground, and near together in such a way as to give ground for the belief that formerly Indians were buried in the ground and not in regular cemeteries. Such deposits exist at Doswailopsh, among the Twanas, and at Duginess and Port Angeles, among the Klallams. These graves were made so long ago that the Indians of the present day profess to have no knowledge of the occupants, but believe them to have been their ancestors. They care so little however about the remains that fifteen years ago the land containing bones at Doswailopsh was taken by a white man, and they were told to remove the dead before all traces of the graves were obliterated, but no one went there to do so, nor were they angry when the underbrush of the cemetery was burned and the ground plowed and levelled.

Formerly when a person died, the body was placed in a box which was put in a canoe, and the canoe placed in the forks of two trees and left there. There was no particular cemetery, but the body is said to have been left near where the death occurred. The Skokomish Valley was once, I am told, full of sepulchral canoes. An old resident informs

me that the Klallams always buried their dead in a sitting posture, and I am satisfied that the Twanas at least bent theirs up until the knees nearly touched the chin.

The following is an account of a modern burial of this kind which I witnessed in October, 1877: The deceased was about thirty-five years of age and was a widow. Her father took charge, and being an old man there was more of the old Indian style than I ever saw before. She died about 9 o'clock in the morning and at 3 o'clock in the afternoon I was invited to go to the house and hold a religious service. When I arrived she had been placed in a Hudson Bay Company's box, which was only about  $3\frac{1}{2}$  feet long,  $1\frac{3}{4}$  wide, and  $1\frac{1}{2}$  high. She was much emaciated when she died or they could hardly have put her in the box, even by doubling her so that her knees nearly touched her chin. A fire was still burning where many of her things had been consumed according to their custom. Her mother was singing a mourning song, others joining in it at times, often saying, "My daughter, my daughter, why did you die?" About thirty persons were present and all out of doors, the coffin box being under an old shed. I held a funeral service and returned home, having been invited to go to the grave the next day. About 9 o'clock the next morning they called for me and we went in a canoe 3 miles to the cemetery, two other canoes having preceded us, one carrying the corpse. Sometime previous a medicine man had asked the deceased to become his wife, but she had refused, and he had said if she did so, he would kill her by his "tamanous." This, her friends believed, was the cause of her death, and they compelled him to give the canoe (25 feet long and worth \$30) in which she was buried. Four boards of old Indian make, about a foot wide and  $7\frac{1}{2}$  feet long, used as posts, were secured in the ground to the depth of a foot and a half. Before being erected a hole was cut in each post 2 feet from the upper end, and 5 inches square, in which cross-pieces were placed for the canoe to rest on. As each hole was cut, and the board laid aside until the rest were ready, a handful of green leaves was placed over it which was allowed to remain until the post was ready to set up, when the leaves were thrown aside. Leaves were not however put on the last board, for as soon as the hole in it was cut, they were ready to set all of them in their places. Two other boxes, which I presume contained many articles belonging to the deceased, or brought by her friends, were placed in the canoe, together with the coffin box, and the whole was elevated to its position and braced. Over the central part of the canoe, a roof of boards covered with white cloth so as to more than cover all the boxes, was placed, and holes cut in the canoe so as to render it valueless for travelling. On the two posts nearest the water the head-board and foot-board of her bedstead (American make) were nailed, and on each of these a dress was fastened. I then said a few words to them and pronounced the benediction, when all went down from the hill to the beach except her father,



mother, and brother, who remained for ten or fifteen minutes mourning and pounding on the canoe.

It was now half past 1 P. M., and a little food was given to all, there being twelve men and three women present, after which the father and mother of the departed made presents to all. One man received a gun, two persons a blanket each, and the rest \$1.50 each. After this four men made short speeches in their native language which I did not understand.

They said she was buried in this way because she was a prominent woman, and that in about nine months a potlatch would take place very near where she was buried, and that as each tribe should come, a few of their prominent men would be sent to the grave with presents, after which she would be put under ground. The predicted potlatch took place about thirteen months afterwards, but she still remains in the canoe.

*Scaffold burial in cemeteries.*—Unprincipled white men having stolen many of the canoes in which their dead were placed, induced these Indians to adopt a different mode of burial. Instead of placing them in forks of trees they collected their dead in cemeteries, placing them in boxes or canoes on scaffolds. The ruins of such a grave-yard now remain about 2 miles from the agency, but nearly all the dead were removed some years ago.

In March, 1878, two Twana children, related to one another, died almost at the same time—one was the child of a medicine man. All of the tribe, it is said, were invited to the funeral; about fifty went, but not a single child among them. They went to the cemetery,  $3\frac{1}{2}$  miles distant, in canoes, with much mourning. When they arrived at the cemetery the medicine man tore down an inclosure where two of his children had been buried with four other children, relations. Another medicine man, belonging to the same clan, also tore down an inclosure where the bodies of two of his children were placed along with those of two others, their relations. Two of these corpses were above ground and two below. The coffins beneath the ground could not be taken up, but the clothes around the bodies were so well preserved there was no difficulty in removing them. One of the coffins was large enough to hold two children, and other rude boxes were made of such capacity as to admit of twelve children being put into eight of them. In one case it was found impossible to place two of the bundled bodies in the same coffin, whereupon the cloth which was wrapped around one was roughly torn off, a little calico wrapped around the skeleton, and then it was put in with ease.

A large grave was dug near by, about 12 feet long and 5 feet wide and 4 feet deep, lined with mats, and all the boxes and coffins were placed in it, completely covering the bottom of the grave. Several of these boxes were wrapped with many thicknesses of calico, and quilts, blankets, shawls, calico, and a few fancy articles of bead-work and a few



small boxes were placed in the coffins with the bodies. All the coffins were next covered with several layers of calico, blankets, mats, and cedar boards to the depth of about 8 inches. An old man then made some remarks, followed by a speech from the child's father, and when this was concluded the grave was filled with earth, a little new calico having been thrown in with the dirt. Next all gathered on the beach, a fire was built on which two or three pieces of cloth were burned, a few men made presents to the fathers of the children just deceased, some calico was given by the women to the mothers, and the two fathers, with another medicine man, presented small sums of money to the men.

#### RELIGION.

The practical part of their religion is a compound of Shamanism and Spiritism, called in Chinook's jargon *tamanous*, *tamahnous*, or *tamanamus*, and the word expresses their idea so completely that it has been somewhat adopted into English, for the word expresses a combination of ideas for which we have no exact English equivalent. *Tamanous* is a noun, and as such refers to any spiritual being, good or bad, more powerful than man and less powerful only than God or Satan. Hence the being may be a good or bad *tamanous*. It is also used to express the work of influencing any of their spirits by incantation. The word is also an adjective, and as such is used to describe any stick, stone, or similar article in which spirits are at times supposed to dwell, and also any man, as a medicine man, who is supposed to have more than ordinary power with these spirits; hence we often hear of *tamanous* sticks and *tamanous* men. It is likewise a verb, and to *tamanous* is to perform the incantations necessary to influence these spirits. In some cases it is done mainly by the medicine men, but in others by any one.

*Objects and implements of worship.*—I do not believe that these Indians ever had any idea of the Great Spirit before the coming of the whites. They have however a plain idea of a great being, perhaps mythological, who has much to do with the world as it now is, and who is called in Twana and Nisqually *Do-ki-batt*, and in Klallam *Mi-ki-matt*. The word means a changer, and considering his work, it is an appropriate name. When he was here he was supreme, and they think he may have a second coming at any time.

*Demons.*—They firmly believe in the presence and power of malignant spirits, and much of their *tamanous* is to conquer them and to gain their favor and aid. The chief of these demons, according to the Twanas, is *Skwai il*, who resides below, but in another place from the disembodied human spirits. Often a parent tells a child, "You must not steal or do wrong; if you do, *Skwai-il* will see you and take you to his dwelling-place."

*Angelic spirits* they believe to be constantly around. Every man and nearly every woman formerly was thought to have one which was called

his or her tamanous. Such a spirit was supposed to guard the man or woman who often communed with it in the dark, when alone in the woods, and, by various incantations, invoked its aid in time of need. These angels were the most useful deities they had.

*Inanimate objects, images, pictures, etc.*—They believe that these spirits, both good and bad, may dwell at times in certain sticks or stones, hence these sticks and posts become objects of reverence. The sticks are generally revered at all times, for, although the spirit dwells there only a small portion of the time, yet after it has been given to the spirit by its earthly owner that spirit is supposed to always watch over it and be angry with any one who treats it disrespectfully.

*Tamanous water.*—It was believed that formerly the Klallam Indians of Elkwa possessed a mysterious power over all other Indians; that if they wished to call a person a long distance off, 20, 30, or 50 miles away, they simply, talking low, called him and he came; that if they talked thus about a person, his heart was in a complete whirl, and that if they talked ill and wished to do evil to any one thus distant, his eyes were made to whirl and the evil wish came to pass. The cause assigned for this was as follows: Far up in the mountains at the head of the Elkwa River are basins in the rocks; one of these is nearly full of black water and it is always as full whether the weather is wet or dry. In this water, which is thought to be tamanous, the Elkwa Indians washed their hands and arms and thus, it was believed, gained their dreaded power.

*Idols.*—The sticks, posts, and the like just described are made by the Indians consecrated to this tamanous, and hence contain the principle of idolatry.

*The sun.*—An old Klallam man informed me that before the coming of the whites they knew nothing about God, but worshiped the sun as their God and they prayed to it daily, saying, "Sun, take care of me," and they gave food to it at noon. Another Klallam told me that they also believed the sky to be supreme, and that it was a common saying of the old ones to their children, "You must not do wrong or the sky will see you." Such ideas come to the surface but very little in their intercourse with the whites, yet I think my informant spoke the truth, and I quote the following from Swan's "Indians of Cape Flattery" in corroboration: "Every night we wash and rub ourselves with cedar and every morning talk to the great chief or his representative, the sun, whose name is Kle-sea-kark-tl," while the following note is added by Mr. Gibbs: "Among the western Selish or Flathead tribes of the Sound I have not detected any direct worship of the sun, though he forms one of their mythological characters. He is by them represented as the younger brother of the moon." According to Father Mengarini he is, however, the principal object of worship among the Flatheads of the Rocky Mountains or Selish proper, as well as by the Blackfeet. Among both tribes he was supposed to be the creation of a superior being.

*Sacred legends.*—They have a distinct tradition of the flood which I modify a little from the one given in Eells on the Twanas: "The flood was sent because the people were wicked, and it overflowed all the land except one mountain. The people fled in their canoes to the highest mountain in their country—in the Olympic range—and as the water rose above it they tied their canoes with long ropes made of cedar limbs to the highest tree; but the water rose above them. While they were there some of the canoes broke from their fastenings and floated away, so far that they never returned, which accounts for a few being left in the tribe (Twanas) now."

*Ecclesiastical organization.*—Medicine men are numerous, and are feared because of the power they are supposed to have with spirits. They demand large fees, and sometimes in advance, for healing the sick. If the medicine man does not consider the amount offered sufficient, he will do nothing until enough is given to satisfy him; but if he fails to heal he gets nothing, and sometimes has to pay the relations of the deceased for his failure. He also receives pay for other work he is supposed to do, such as making a person sick at the request of an enemy. The calling is confined to the men among the Twanas; but at a Twana potlatch a Skwâksin woman acted as doctress, and there is at least one medicine woman among the Klallams at Elkwa.

There are no rain makers; but at Eneti there is on the reservation an irregular basaltic rock about 3 feet 4 inches in diameter and 1½ feet high. On one side there has been hammered a face, said to be the face of the thunder bird, which could also cause storms. The two eyes are about 6 inches in diameter and the nose about 9 inches long. It is said to have been made a long time ago by a man who felt very badly and went and sat on the rock and with another stone hammered out the eyes and nose. For a long time they believed that if the rock was shaken it would cause rain; because the shaking made the thunder bird angry. They have now about lost faith in it, so much so that about two years ago they formed a boom of logs around it, many of which struck it. That season was stormy and many of the older Indians said "No wonder, as the rock is shaken all of the time." It is on the beach facing the water where it is flooded at high tide, and the impression is being gradually worn away by the waves.

*Finding tamanous.*—The first thing for a young man to do in the way of a sacred rite is to get his tamanous. In order to accomplish this I am told that a father would send his son into the woods a long way from home, where he was not allowed to eat or drink during a period of from ten to thirteen days, though he was allowed to bathe often and keep up a good fire. At last his tamanous revealed itself to him in the shape of some animal, either a bird or beast, which was afterwards sacred to him. They think that ordinarily such fasting would kill a man, but that he is kept alive by his tamanous.

*Using tamanous.*—After this the Indian tamanouses for what he wishes



very earnestly on somewhat the same principle that the Mohammedan prays. Hence they tamanous for wind, for gambling, and to cure the sick or cause sickness.

A wicked medicine man can, as they believe, in an invisible manner shoot a stone, ball, or poison into the heart of a person to make him sick. They believe this so firmly that they say when the heart of one who died was opened the stone or bone has been found in it. He is also supposed to be able to send a woodpecker, squirrel, bear, or any treacherous animal to the heart of his enemy to eat his heart, plague him, make him sick, or kill him. The good medicine man finds out from his sickness what kind of an animal it is and then tries to draw it forth, and while the common people make a noise, pounding on a rough drum, on sticks, halloing, singing, etc., the medicine man places his hands on some part of the body and draws forth, or says he does, the evil spirit, and when he says he has it he holds it between his hands, invisible, and blows it up or takes it to another man who throws a stone at it and kills it. When the sick person is not cured they say there are several evil spirits, but sometimes the person dies before they are all drawn out or else the opposing medicine man is stronger than he and so he can not draw them all out. Sometimes the good spirit of the person is gone and he is sick. Then the medicine man draws them all out. Sometimes the good spirit of the person is gone and he is sick. Then the medicine man tries with his hands to draw it back and so cure him.

The first time I ever saw an Indian doctor perform over a sick person was in October, 1876. The patient was a woman of perhaps fifty years. As I went to the house a prominent Indian came out and told me that although they had sent to the agency physician for medicine, yet they were not certain where she was sick. At times she could not see, she would know almost nothing, and could not tell where she was sick, and they were tamanousing to find out what was the difficulty, and when they had learned this they would send and obtain the right kind of medicine. They say that they often do tamanous, first in order to learn what is the difficulty and afterwards to cure. Having asked permission, I went in and took my seat, as directed, behind the doctor, so that he was between me and the patient. The house was about 20 feet square, a summer house, built on the gravelly beach of the Skokomish River. There were about fifteen persons in the house, both men and women, all of whom while the doctor was performing beat with small sticks on larger ones and sang in regular time. I was in one corner of the house, the patient (female) in the opposite corner facing me, sitting up and held by another woman. There were two fires near the middle, and the doctor was between them on his knees on the gravel. He was stripped to the waist, having only pantaloons and boots on, and faced the woman. He had a small tub of water near the woman. As he began he almost laid down on the gravel and sang and kept swinging his head up and down, constantly singing, while the other Indians joined



in the singing for about twelve minutes, when he began to vomit violently over himself and the ground. Then came a rest of a few minutes, when he rested and washed himself off. But soon all began again, when he worked up to the woman and, as near as I could see, placed his mouth on her chest or shoulders and sucked very strongly and then blew out of his mouth with all his force, making a great noise, sometimes blowing into the air, always remaining on his knees. This was kept up about fifteen minutes longer, when I left during another respite. But this was neither the beginning nor end of the tamanous. Sometimes they kept it up for most of the day and night or longer. The agency physician said she had disease of the brain, but at no time was very dangerously ill. He afterwards attended her very faithfully, and the Indians tamanoused as faithfully, and she recovered. The following account was given me by a school-boy in regard to his brother:

“When I was at the Indian doctor’s house they tamanoused over my brother, for that is the reason my parents went to his house. First, he learned what was the kind of sickness. The doctor took it and soon after that my brother, about nine or ten years old, became stiff and while I sat I heard my father say that his breath was gone. I went out, for I did not wish to see my brother lying dead before me; when I came back he was breathing just a little but his eyes were closed; the doctor was taking care of his breath with his tamanous and waiting for more persons to come, so that there should be enough to beat on the sticks when he should tamanous so as to learn the kind of sickness. Then he went on and saw that there was another kind of sickness besides the one he had taken out and it went over my brother and almost immediately killed him. The doctor took it and travelled (in his spirit) with another kind of temanous to see where my brother’s spirit was; he found it at Humhummi (15 miles distant), where my parents and brother had camped in a recent journey. So my brother became better after a hard tamanous.

“There is a class of persons which we can not see; they are poor looking persons; they take young people from these and other Indians; when they take a certain person that person always gets crazy. Another brother of mine heard their dog barking; the people thought it was from some white people, but there was no white man near and they knew it belonged to these people.”

I once witnessed a performance which I have been inclined to call a silent tamanous. I was camped with five canoes of Indians one night in February, 1878, one of our number being a medicine man; after supper some water was poured into a bowl not far from a woman who I had not learned was ill, but she must have been ailing a little; she was sitting perhaps 10 feet from me. The doctor went to the bowl but no one else seemed to take any notice of it; the woman’s husband went away. Another woman lay unconcerned in the camp, it being a half-circle mat house, and other Indians were about, but they did not come near; there

was no noise or singing, or pounding on sticks or drumming; the doctor put his hands in the water, warmed them a little, and then placed them on the woman's side, her dress having been opened and partly taken down for the purpose, and he acted as if he were trying to draw out something. This was done a second time, when he plunged them into water, placed his mouth next to them and blew suddenly and powerfully a few times; this was done two or three times, when he left, the performance being ended.

*Tamanousing for lost souls.*—Sometimes before a person dies, it may be months, it is supposed that a spirit comes from the spirit world and carries away the spirit of the person, after which the person wastes away or dies suddenly. If by any means it is discovered that this has been done, and there are those who profess to do it, then they attempt to get the spirit back by a tamanous, and if it is done the person will live. Sometimes a person who has much intercourse with the other world persuades one who is in the best of health that he has visited the spirit land and seen the spirit of his dupe there, and the latter is thus frightened into having a tamanous. Again, when some credulous individual has been ailing a little for a long time, but not sufficiently to feel that he needs to employ a medicine man, one of these arrant humbugs takes a fancied journey to the land of shades to search for the lost soul of the invalid, the discovery of which he soon announces, and once more there must be a tamanous. Frequently in the winter when time hangs heavily on their hands and they are at a loss for amusements these soul searchers pretend that they have received tidings of a number of errant spirits and they get up a general spirit hunt.

In January, 1878, a tamanous of the last kind took place among the Twanas, and I learned the following facts concerning it from one white man and some school-boys who were present:

The performance is carried on mostly in the night, as it is said that day-time with us is night-time in the spirit world, and *vice versa*. The breaking of the ground is an important part of the ceremony. The surface of the earth is often actually broken in order, they say, that the spirits of those who are performing can descend into the other world. When, as they pretend, the descent is accomplished, they represent pantomimically that they travel along a road, cross at least one stream, and travel on until they come to a place where the spirits dwell. These they surprise and engage in fight (a great noise is here kept up by all present), and having captured they bring back to this world the spirits of three persons which they pretended to roll over up in cloth and work for some time, after which they seemed to give them to their real owners. When they put the spirit of one man on him, he sang his tamanous song, and when a medicine man received his, he cried very much. Only men enact the part of travellers in the nether world, although women and children are present at the tamanous. When they are supposed to cross the stream they actually set up some boards against opposite sides

of a beam in the house which is about 10 feet from the ground, thus **A**, to represent the bridge. They crawl up the board on one side and down the other. If, in going down, a man slips they believe he will die within a year. Several years ago it is said a man did slip on such an occasion, and as he died within a year they are convinced of the truth of this belief. Only eight men went through this journey at one time, but the rest of the numerous body in attendance pounded sticks and sang their tamanous songs to the accompaniment of the drum.

While performing they danced with the hand sticks around the idol. They also wore the head-band. The house in which this took place was built the previous season for this purpose, and was similar to the large dwelling-house. I am told that when they are professing to fight with the underground spirits and conquering them they break through the sides of the house, which are not very strong, and run outside accompanied by all the spectators. At times they also profess to bring berries from the other world, and if so, the bushes in this world will bear abundantly the next season.

*Black tamanous rattle.*—In the black tamanous a hollow rattle is used. To make one pieces of wood are carved and hollowed, small stones or shot are placed between them, and they are fastened together with bark at the handle and strings at the sides. Such rattles are usually painted black, and are shaken in the hand with a circular movement. They are not now used by the Twanas.

*Purification.*—When a young man went forth to obtain his tamanous he washed himself, much as already described, this cleansing being very essential. A Klallam doctor told me that the children, if they wished to become strong tamanous men, were accustomed daily, both summer and winter, to bathe, remaining in water a long time, sometimes, he said, for hours, supposing they thereby gain the favor of the tamanous. He said that he did so when young.

#### BELIEFS.

*Dreams.*—The following story of a dream was told me by the medicine man who dreamt it: A child of his died and he felt very sorry about it, crying much of the time. One night he went to sleep and dreamed that some one came to him, similar to the picture of an angel which I had shown him, and took him off to the other world, leading him at first by the finger-nails. They went till they came to where the roads forked, one going up towards the good land and the other downwards. He was led in the lower one where there was no fire and where it was very dark. A tree or stick stood between the two roads, and his leader jumped on it and thence to the upper road and laughed at him, saying he could not jump so, but if he did try he could not get into the good road and go to his child. He however made the attempt, and in two jumps reached the upper road, and they went up until they came to a house, at which his leader knocked. They were admitted, but there was



no one in the house save an old man, who told them that the child was farther on. They proceeded until they came to a prairie where was excellent grass and some sheep, which were very lean and did not eat. Next they came to a barren land where were some fat sheep, and again to a good grass country with lean sheep. After a time they reached a hill where were some children and persons singing, and his leader told him that his child was among them, but that he must not go over the hill and see the child. The spirit then gave the dreamer some maple leaves and huckleberry leaves, telling him that the maple leaves would be a girl and the others a boy, as children for him. He was also told that he must not cry for his child as he now knew that it was safe, and that he must not cry for other friends, as his wife or mother, if they should die; but if he felt very sad he might cry for three days.

The man says that since that time, when a friend of his has died, he only mourns for three days. His leader also told him that this world would come to an end in three years.

*Snakes.*—There is a tradition among the Twanas that a long time ago they were not afraid of snakes, but that one man killed several, and at last killed the king of snakes. Then all the small snakes gathered together and attacked the man, fastening themselves to his mouth, eyes, ears, nose, face, and in many other places, and bit him, and killed him, and now they are afraid to kill or even approach a snake.

*Future existence.*—Their belief was that the next world was neither above or below, but somewhere within the earth. There was only one place for all, both good and bad.

*Incarnation.*—The tribes under consideration, as well as the others in this region, have a tradition that a great being called the changer went all through this region and did many wonderful things. Whether this be a dim tradition of the incarnation of Christ, or not, I can not determine; but I have thought it might be. When the Indians first heard of Christ they associated him at once with the changer, whom they said they believed to be the great Creator. When I have been teaching them about the coming of the Savior they have said they always knew of this, and have repeated some of their legends about the changer, our God and this mythical being having the same name in the Chinook jargon, Saghale Tyee, but in the native language they have different names.

God is called, in Twana, Wís-só-wul-us; in Nisqually, Shuk-si-ab; and in Klallam, Tsílt si—all of which, as well as the Chinook, Saghale Tyee, means the above chief, while the changer is called by the Twanas and Nisquallies Do-ki-batt, and by the Klallams Nu-ki-matt.

The following are the traditions concerning him:

Klallam traditions express some uncertainty as to who this being was, but they usually consider that it was a woman who came from the south and changed human beings into lower animals and inanimate objects. Protection Island, at the mouth of Port Discovery Bay, was



once, they say, a part of the main-land, and it and the main-land were a man and his wife, but the man became vexed with the woman and kicked her away, and when Nukimatt came she changed them into land as they are now.

The mountain back of Freshwater Bay, about 9 miles west of Angeles, was, according to tradition, a woman, and Mount Praher, in British Columbia, was her husband, both living near Freshwater Bay, while the large rock off the cape at the western end of the bay was their daughter. The woman was bad and abused her husband; he bore it for a long time, but at last took his things, put them in his boat, and went across the Sound to where the mountain now stands. When Nukimatt came she changed them all into what they now are.

One Klallam has told me that they supposed that the sun was the creator of the world and that when Nukimatt came she was the sun incarnate. Another name for her was I-nach-tū-ak.

Dokibatt, the Twanas say, was the creator of all things, making birds beasts, and all lower creatures before he made man. According to one Indian he made the moon and sun, the moon first and in the night, intending it to be the sun. In the morning it rose, but it shone too hot and caused the water to boil, killing the fish and also many animals on land, and did much damage generally, so then he made the sun as it now is to rule the day, and condemned the moon to shine at night. This tradition differs only a little from one given in Eells on the Twanas. He created man out of the ground and a woman out of his rib and gave them a good land, telling them they might eat of all the fruit except one kind of berries. But the woman, tempted by the king of evil spirits, Skwai-il, ate of those berries, and when Dokibatt came he said, "Have you been eating of those berries?" She said "No." He replied, "Yes, I know you have." On account of this they think that her children became Indians, ignorant, foolish, and dark-skinned. But the man did not eat of the berries, and to his children were given letters, the knowledge of books, and a white skin.

A long time after this Dokibatt came again to this world because things were not good, and rectified them by changing them, hence his name, which means a changer. The man, knowing that Dokibatt was coming, sat down and began to whet his knife on a stone, saying, "I will kill Dokibatt when he comes." Soon he came and asked the man, "What are you doing?" "Nothing special," was the reply. Again the same question was asked, with the same reply. Then Dokibatt said, "I know what you have said; you want to kill me. Let me take your knife." He took it and felt of its edge; it was very sharp. He plunged it into the leg of the man up to its handle, when the man began to jump, and jumping away became a deer; and that knife slightly sticking out is still seen in the legs of the deer (the small part behind, as I understand). Acting similarly with his knife he was changed into a beaver, his knife becoming the tail.

Another person was pounding against a cedar tree, and Dokibatt asked him what he wished to do. The reply was, "To break or split the tree." Dokibatt said, "You may stop and go away and I will help you." As the person went wings came to him, also a long bill and a strong head, and he became the woodpecker.

A boy who knew that Dokibatt was coming to make great changes was in mortal fear, as he did not wish to be changed; so he began to run away, carrying with him a water-box with some water in it; but as he ran wings came to him and he began to fly. The water shaking sounded something like pû-pû-pû repeated rapidly, and the sound was changed into the present noise of the bird as it begins to fly. So the dove then began its present mourning cry, "hûm-ô-hûm-ô." And the Twanas to this day call the turtle-dove "hûm-ô."

Other men had painted themselves in various ways, and when they were changed the colors partially remained; hence the different colors of various birds.

About a mile above Silanwofs are two large impressions in the basaltic rock, somewhat similar to large foot-prints, 2 or 3 inches deep. These, they say, are his tracks. They are between high and low tide, and were evidently formed by the water.

At Skwaksin a man was crying, and the tears running down his face he was changed into a stone, and the lines of tears are lines on the stone, still visible.

He taught them how to catch fish, how to make the fish-traps, and when to fish.

He went to all lands, gave to each tribe their language, and to some tribes special kinds of food. To one tribe he gave crows, to another a special kind of fish, and to one beyond the Cascade Mountains snakes. He came from the south or west, where they suppose the sky comes down to the earth, as it appears to do, and that is his dwelling place. He came once to create, a second to change, and will come again to make the world over again when it becomes old.



## ANCHOR STONES.

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By B. F. SNYDER, M. D., of *Virginia, Cass County, Illinois.*

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In the study of American antiquities we meet with many objects of pre-historic art that baffle our comprehension, for the reason that we are ignorant of many of the methods of life and the superstitious observances and religious rites of the ancient people who wrought them. Of this class the so-called "plummets," "discoidal stones," "gorgets," "amulets," and "banner stones" are mysteries to us, because their original purpose is unknown, our civilization admitting of no use or necessity for them. The names we have assigned to them are sometimes misleading, and even the uses to which recent Indians have applied them can not be relied upon as correctly indicating their true design. Thus, Adair, Lawson, Timberlake, and others have described the game of *Chungke* which they saw played by the Mandans, and by the Cherokees, Creeks, and other Southern Indians, with discoidal stones; but neither they nor any other white persons have ever seen an Indian *manufacturing* a discoidal stone; and because recent Indians utilized them in their games, it is by no means conclusive that they may not have found them already made, as we do, or that they were not as ignorant of the specific service for which their remote ancestors made them as we are.

But, on the other hand, it is reasonably certain that many of the ways and means of obtaining subsistence employed by the earlier aborigines were identical with those practiced by the Indians here who first met the invasion of Europeans and sullenly receded before it. In securing food by hunting and fishing all primitive people, the world over, yet unacquainted with the use of metals, resorted to very much the same arts and appliances. The bow and stone-pointed arrows and spears, bone fish-hooks and harpoons, rude traps, nets, and seines were the inventions and contrivances alike of peoples widely separated and unknown to each other. To savages who had progressed so far as to venture upon the water, on rafts or in canoes for catching fish, the necessity of remaining stationary while so engaged would soon become apparent, and the means for accomplishing this would naturally suggest the employment of some heavy substance resting on the bottom of the lake or stream as an anchor. A stone would be the most readily and conveniently supply this want, and almost anywhere along the shores of



our rivers and lakes stones of requisite dimensions for such use could be easily obtained. Rough stones, demanding no labor for their preparation, were probably so used since the first canoes were launched. Taken from the nearest point when needed, they were cast aside at any place when no longer wanted, bearing no mark or sign of their service. In some instances the same stone was repeatedly used as an anchor during the fishing season, and received from the fisherman some modification of form to better fit it for its office, and in a few exceptional cases the anchor stone was completely and artistically fashioned from the rough, angular rock. In one respect the aboriginal American did not materially differ from a numerous class of his civilized successors; he had no especial fondness for manual labor. Consequently, it is not surprising that he expended so little work on his stone anchors when he found them to answer his purpose as well or better without it.

Of the very few *manufactured* anchor stones, presumably of pre-historic date, of which we have any account, I have been so fortunate as to secure a fine specimen, which is figured on page 194 of the elaborate monograph on Prehistoric Fishing, by the late learned curator of the department of antiquities of the Smithsonian Institution, Dr. Charles Rau, accompanied by a brief description of it by myself in a note I addressed to the author. Before reproducing that description here I will describe the first specimen of the kind that came into my possession, and which was also mentioned in my note referred to.\*

This anchor stone, represented by Fig. 1 (accompanying Plate I), I stated to Dr. Rau, was "apparently natural in its form; a smooth, water-worn river rock, etc." A subsequent careful inspection of the stone proves this statement to be not altogether correct. By attrition and the force of water currents it had probably approximated its present shape in general outline; but it is plainly to be seen that its smooth, rounded edges and uniform surfaces have been wrought with patient labor guided by consummate skill. There is little doubt that this stone was designed to serve a double purpose; or, having been made for a specific use, in which it did duty for a time, was afterward converted, by cutting the groove across it, into a canoe anchor. In diameter it is 12 inches, in thickness  $2\frac{1}{2}$  inches, and weighs 26 pounds. It is nearly circular, and its surfaces are concavo-convex; the one side convex to the extent of rising in the center three-fourths of an inch above the plane of its circumference, and the other side has been hollowed out to a corresponding depth. Across its face and over the edges a groove has been cut an inch and a quarter wide, but not deep; sufficiently deep, however, to clearly indicate its use—or one of its uses—as an anchor. It is a white, crystalline limestone, from one of our local carboniferous strata that crop out in many places on the Illinois River. But for the vertical groove in this specimen it would not differ materially from many others found here and

\* Prehistoric Fishing, pp. 194, 195 (Smithsonian Contributions to Knowledge, Vol. xxv).

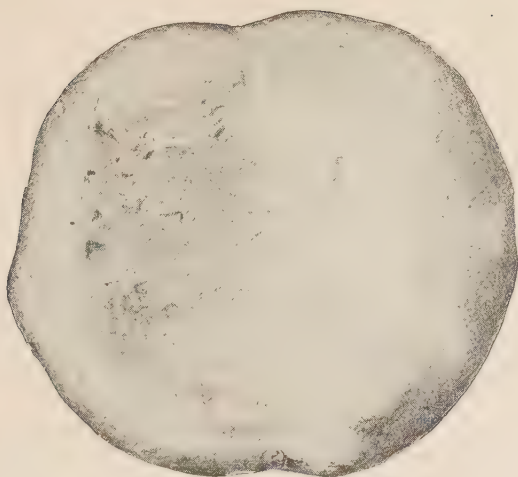


FIG. 1.—(1.)

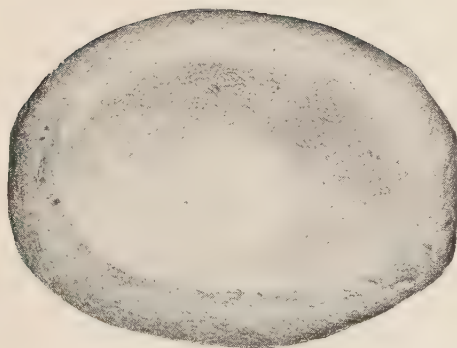


FIG. 2.—(2.)



elsewhere in the Mississippi Valley, having on one side, and sometimes on both, shallow, basin-like depressions artificially scooped out. Stones of this character are found of various dimensions and different kinds, and are commonly known as "mortars," the general belief being that they were used in some inexplicable way for grinding grain with the aid of pestles, somewhat as the *metate* is still employed by the Pueblos and Mexicans. Fig. 2 (Plate I,) represents a typical specimen of the objects mentioned, now in my collection. It was found near the bank of the Illinois River in excavating a cellar in the city of Beardstown, in this county, on the site of an ancient Indian camping ground. It is a smooth, water-worn boulder of hard greenstone (diorite), with both sides hollowed out dish-like to the depth of almost an inch at the center below the edges. It weighs a fraction over 15 pounds, is  $9\frac{1}{2}$  inches in length, 7 inches wide, and  $3\frac{1}{2}$  in thickness at the circumference; with rounded borders smooth, excepting at both ends, and on one side for a space the stone is roughened and battered as though it had been used as a maul for breaking other stones, or as an anvil upon which hard substances had been hammered. Fig. 3 (Plate II) is another so-called mortar of the class most frequently found, from one of the counties in the southern part of this State (Illinois); a rough block of granite weighing 16 pounds, with smoothly-worn depressions on both sides. The excavations in all the objects of this class, including Fig. 1, are so insignificant, so shallow and broad, as to preclude their supposed use as mortars. "Dished" stones of this character are comparatively common in southern Illinois and farther east on both sides of the Ohio River. And in the same territory stone mullers, of which Fig. 4 (Plate II) is the ordinary type, are also frequently met with. The correlation of the two implements is a natural inference at first sight, but the experiments I have tried with those in my collection satisfied me that the two implements were not used together. I could find none of the pestles to fit the mortars. The pestles have broad, flat bases not adapted to concavities, and must have been used, if used as *pestles* at all, on plane surfaces, as our painters of a generation ago employed similar stone mullers for grinding their paints on broad, flat slabs of marble. The "dished" stones, in my opinion, are simply the rubbing-stones, or whetstones upon which, with the aid of sand and water, the diorite axes and celts received their cutting edges.

The anchor stone I was describing when led into this digression was found in a small sand mound, 15 feet in diameter and 2 feet high, a short distance from the Illinois River, in the suburbs of the city of Beardstown. The mound covered the much-decayed skeleton of a large, middle-aged individual, who had been laid on the surface of the ground, on his back, at full length, with feet to the west and arms extended down his sides. The back of the skull rested in the concavity of the stone, which had been placed as a pillow under the occiput of the corpse. Under each shoulder and under each elbow, each hip and each heel of the skeleton, was found a common, smooth, water-worn



pebble, of the average size of a hen's egg; in or near one hand, seven flint arrow points; and in or near the other hand, three large scales of the alligator gar—that perhaps had also served as arrow points—completed the sepulchral deposit.

My second anchor stone, Fig. 5 (Plate II), the one figured in Prehistoric Fishing, was brought up from the bottom of the Illinois River half a mile below the confluence of the Sangamon, by one of the Government boats employed in improving the channel for navigation. It is of compact, yellow sandstone, the most prominent rock of the coal measures underlying the Sangamon and Illinois bluffs in this county. It weighs  $34\frac{1}{2}$  pounds; is symmetrically proportioned; circular in contour; 12 inches in diameter by  $6\frac{1}{2}$  in thickness at the center, with neatly rounded edges, and is encircled by a groove,  $1\frac{1}{2}$  inches wide and three-fourths of an inch deep, cut across the face equally on both sides. The surface of the stone is not smooth, but presents the appearance of having been "bush-hammered"—to use a term of modern stone-cutters—the result of pecking with sharp-pointed flints or other hard stones. The groove around it is regularly and skillfully cut, and shows throughout the pitting of the pointed stone instrument that shaped it.

Not long after the recovery of this anchor stone the dredge brought up another one from the bottom of the river, at a point 2 miles farther down stream, that was almost an exact copy of the one I have just described, in material, dimensions, and form. Unfortunately it escaped the notice of any one capable of properly appreciating its value, and fell into the possession of an ignorant German who at the time was employed as a laborer on the boat. His estimate of this interesting nautical relic was more practical than scientific; and carrying it to his home he there utilized it as a weight in the family kraut barrel that stood in a corner of his kitchen. In this ignoble service I found it and attempted its deliverance; but, suspicious that my desire to obtain the stone sprung from a secret knowledge of some extraordinary intrinsic value it possessed, neither price nor persuasion would induce the kraut-eating plebeian to part with it, and I sadly left it in its vulgar obscurity. Before another opportunity was presented for renewing my efforts to secure it the Teuton's hovel was accidentally destroyed by fire, and the much-coveted anchor stone was shattered in fragments by the intense heat.

A few years later, in the same locality, I discovered another anchor stone near the door-step of a small farm house at the foot of the bluffs on the west side of the Illinois. The farmer, who was also a fisherman, found it at the river's edge at low water, and, noticing its peculiar shape and surface marks and the encircling groove, he was intelligent enough to recognize it as an "Indian relic" and mercenary enough to hold it for a good price. This stone anchor had not been finished when it was lost or abandoned by its ancient owner. The rough angles of the rock had been pecked away and rounded with sharp flints and the block reduced to an irregular oval, as shown in Fig. 6



FIG. 3.—( $\frac{1}{3}$ .)

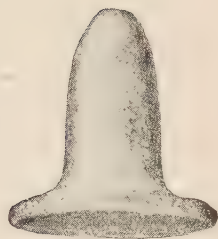


FIG. 4.—( $\frac{1}{4}$ .)



FIG. 5.—( $\frac{1}{4}$ .)



(Plate III). The groove around it is not completed, but cut sufficiently deep to securely hold the anchor line. It is of the same yellow, massive sandstone from which the two last-described anchors were wrought. It weighs 43 pounds; is 12 inches in length,  $10\frac{1}{2}$  inches in width, and 6 in thickness. This stone, like Fig. 1, had served in more than one capacity. Though in general contour each side approaches regular convexity, there is in the middle of each surface a slight, saucer-like depression worn on the side shown in the cut, perfectly smooth; but on the reverse side the hollow is rough and incomplete. The stone bears all over, excepting in the front depression, the pitting marks of the sharp-pointed flints used in its reduction.

The extended researches of Dr. Rau throughout both hemispheres\* in the arts and artifices employed by primitive peoples for catching fish, with all the facilities afforded him by the Smithsonian Institution and his mastery of several languages, have brought to light a very limited number of *wrought* stones designed to serve especially as boat anchors. The conception of making an anchor of a rock was as natural to savages unacquainted with metals as was the expediency of making weapons and tools of stone; but as the rocks in their natural condition were the most efficient as anchors, it is difficult to comprehend why so much labor was expended in cutting any of them to prescribed patterns for this service. The sculptured rounded anchor stones perhaps were part of the equipment of bark canoes, so thin and fragile as to be endangered by carrying rough stones heavy enough to answer as safe anchors; hence cutting down projecting points and angles became necessary as a precautionary measure to guard against accidental scuttling of the craft. If this explanatory suggestion is rejected as improbable or inadequate, we must then ascribe the exceptional flint-chiseled anchor stones to the esthetic element inherent in the Indian. In point of age there is little doubt that these interesting relics ante-date the advent of Europeans. They are certainly the product of Indian art, for the negative reason, if no other, that white men had no incentive and were under no necessity for wasting so much useless labor on such objects. "Stones are still employed," remarks Dr. Rau,† "instead of anchors for small craft in Europe as well as in North America, and probably all over the world. With regard to North American anchor stones, therefore, some discrimination is required to discover whether an object of this class is a relic of the former inhabitants or of their white successors, and there may be cases in which a proper distinction becomes well-nigh impossible. Our fishermen on the great lakes and rivers almost universally use stones in lieu of anchors."

In this respect there can however be no uncertainty as to the antiquity of my first specimen, Fig. 1. Its inhumation with the body of the fishermen who probably made and used it, and its association in the mound tumulus with flint arrow points, are sufficiently conclusive.

\* See Prehistoric Fishing, Washington, 1884.

† Prehistoric Fishing, p. 195.



But with the others their claim to pre-historic origin rests more on pre-sumption and assumption than upon positive evidence. They were sculptured in symmetrical form from rough blocks by precisely the same method employed by pre-historic makers of stone celts and grooved axes, who reduced fragments and small bowlders of igneous rocks to the required shapes of finished implements by pecking them down with pointed pieces of flint or quartz. Of all the stones used as anchors in the historic period (of North America) there is not an instance recorded of one of them having been wrought throughout by this method. But stones are at this day *modified* by the pecking process for use as anchors by Indians, and it may be, by whites also.

A few summers ago my collection was visited by Dr. W. H. Daly, an eminent physician of Pittsburgh, Pennsylvania, as he was returning from one of his annual hunting and fishing excursions, this time to the northern lakes. The anchor stones attracted his notice, and he told me that a few days ago he had seen quite a number (fifty or more) "stones like those, with grooves cut around them," scattered along the lake shore near the town of Bayfield, in Wisconsin. Here indeed was a revelation; enough anchor stones to stock all the museums of our country. I lost no time in writing to a friend at Bayfield, and the correspondence in due time fructified in my receipt of two of the anxiously expected objects, one of which is represented by Fig. 7 (Plate III), accompanied by a brief account of them as follows: "The stones you inquire about, two of which I to-day express to you as requested, are not pre-historic, but very recent. They are the common water-worn bowlders of primitive rocks found everywhere on our lake shores by thousands. The Indians (Chippewas) living up north come down here every spring to fish, and use these stones to anchor their bark canoes while fishing near the lake shore. As the bowlders are quite smooth, and mostly round, the fishermen have to cut grooves around them to hold the anchor lines. This they do very quickly and expertly by pecking the groove out with sharp-pointed pieces of quartz and other hard rocks. When they get done fishing here they leave these grooved bowlders on the shore for use again the next spring. Some are lost by rolling into the lake and others are carried away by floating ice; so they have to be replenished by making new ones every year." Fig. 7, I was assured, was fairly representative of the entire lot. It is a polished boulder of dense, bluish trap, weighing 32 pounds, and is 11 inches in length by 9½ inches in diameter at the middle. The groove is an inch wide and three-fourths of an inch deep, and presents the same pitting that marks the entire surfaces of Figs. 5 and 6.

On receiving the grooved bowlders I immediately wrote to my lamented friend, Dr. Rau, giving him a minute description and drawings of them, and inclosing a copy of the foregoing letter. But his Prehistoric Fishing had then passed through the press, and he answered: "What a pity that your valuable discovery of modern anchor stones came *post festum*."



FIG. 6.—( $\frac{1}{4}$ .)



FIG. 7.—( $\frac{1}{4}$ .)



## ANTIQUITIES IN MEXICO.

By S. B. EVANS.

The town of Tezcoco in Mexico, though uninteresting in general appearance, contains within its limits and vicinity several large mounds, one of which is reputed to be the site of the palace of Nezahyucoatl, and upon it is a female chapel. An Indian is the owner of one of the *tloletes* or mounds and in leveling the base or lower terrace on the western side, for the purpose of increasing the area of his kitchen garden, he recently encountered a large stone which interfered with his plans and set him to work clearing off another portion of the mound. Hearing of this stone, and obtaining permission to lift it from its resting place, I found it to be a section of an ancient monument of porphyry, sculptured in bas-relief. It is 8 feet in length and 6 feet 9 inches at the greatest diameter, the sculpture representing a colossal human figure, a portion of which is visible on this fragment. It appears that it was broken off at the neck and divided down the trunk to the hips, leaving intact the left side, the arm, and a calendar beneath the arm 2 feet in diameter. The left hand is shown with palm turned inward. The calendar, which is near 6 feet in circumference, is provided with an index, which points to a certain place on the dial, indicating probably the time of the dedication of the monument. The surface of this stone shows marks of violence, as is indicated in the drawing (Fig. 1), given on the following page.

There is a gorget on the neck, a decoration on the breast, and hieroglyphics on the arm, representing, according to Mexican authority, phases of the moon. Upon the index of its calendar is a well-defined Maltese cross. The pedestal of this monument was perhaps in the temple, built on the summit of this mound, from which it was hurled by the Spaniards at the time of the conquest.

The mound was about 60 feet in height and had three terraces or stages, traces of which are to-day plainly perceptible.

It is probable that the Tezcoconians whom Cortez found here were the sculptors of this monument. They, as well as the Aztecs of Mexico, were but a wandering tribe of barbarians three hundred years previous to the advent of the Spaniards. They entered the valley in the begin-



ning of the thirteenth century and settled on the eastern border of the lake opposite Mexico. The descendants of these people live in the vicinity of Tezcoco to-day and for three hundred and sixty years have been in contact with European civilization without having acquired much knowledge of civilized arts. They are still the Indians whose highest works of art are the feathered pictures which their ancestors made at the time of the invasion.

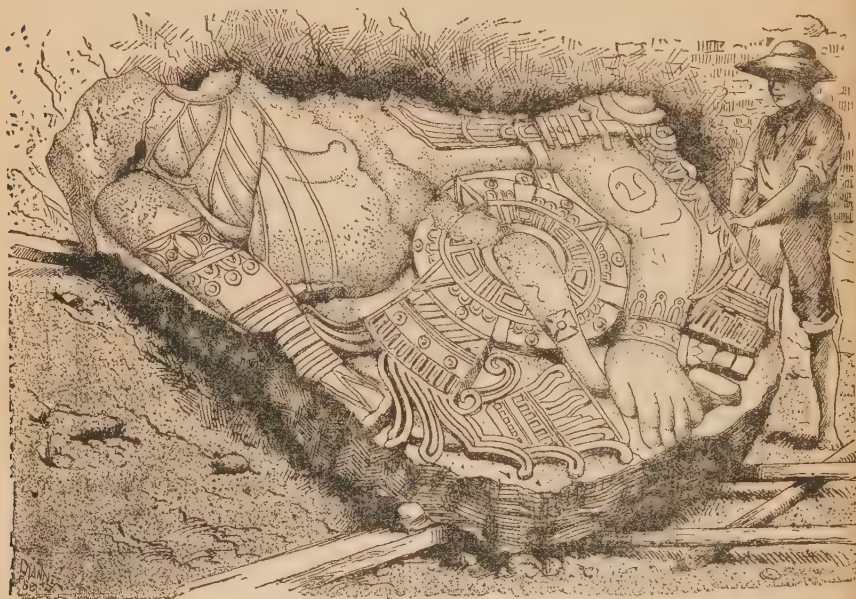


FIG. 1.—Fragment of sculptured porphyry.

If these Indians, whom Cortez found in possession of the soil, were not the authors of these monuments, who did make them? It is quite the fashion to ascribe to the Toltecs everything which is not understood and about which there is a doubt; but there is a grave doubt as to the Toltecs themselves and as to the time when they occupied this valley. It is certain however as to the date of occupation of the Aztecs. It is certain, too, that Tenochtitlan or Mexico was their highest achievement in art or architecture, and Mexico at the time of the conquest, instead of being such a city as Prescott pictures it, was but a collection of mud houses. There were no palaces and there are no remains of palaces in the city of Mexico. Wearied with wandering, the Aztecs finding the remains of a civilization adapted themselves to it the best they could, adopting the idols and blending the religion of the people who preceded them with their own rude idolatry. This is perhaps the cause of the strange contradictions in Aztec remains. In no other way can we account for the defacement of the so-called sacrificial stone by the cutting of a rude channel through its finely sculptured

surface, in which the blood of victims flowed in honor of the fierce Aztec deities. The same theory will also account for the presence of such a work of art as the sculptured slab of Tezcoco in the midst of a collection of mud huts, such as Cortez found and dignified with the name of a city.

The drawing of this "find" (represented in the foregoing figure), was made by Mr. W. H. Bishop, and the following is the translation of the certificate of discovery issued to me by citizen Eugenie Villadosola, political chief of the district of Tezcoco, in the State of Mexico, June 3, 1882:

I certify that Señor S. B. Evans, chief of the expedition sent by the director of the newspaper called the Chicago Times, has presented himself in this town for the purpose of examining the ancient monuments that exist in this district which is under my direction, and having discovered in an excavation that had already been begun a stone that is said to be the ancient calendar stone of Tezcoco, the dimensions and drawings of which he has in his possession, I hereby issue to said Señor Evans this certificate of discovery this 5th day of June, 1882.

EUGENIE VILLADOSOLA,  
*Political Chief.*

ANTONY CÆSAR,  
*Clerk.*

The monument, by order of Señor Mendoza (since deceased), director of the national museum at Mexico, has been removed to the city.



## BIOGRAPHICAL MEMOIR OF ARNOLD GUYOT.\*

By JAMES D. DANA.

It is a remarkable fact in the history of American science that, forty years since, the small Republic of Switzerland lost, and America gained, three scientists who became leading men of the country in their several departments—Agassiz in Zoology, Guyot in Physical Geography, and Lesquereux in Paleontological Botany; Agassiz coming in 1846, Guyot and Lesquereux in 1848. A fourth, Mr. L. F. De Pourtalès, who accompanied Agassiz, also merits prominent mention; for he was “the pioneer of deep sea dredging in America.”† The Society of the Natural Sciences at Neuchâtel lost all four. As an American Academy of Sciences we can not but rejoice in our gain; but we may also indulge at least in a passing regret for Neuchâtel, and recognize that in the life and death of Agassiz, Pourtalès, and Guyot we have common interests and sympathies.

My own acquaintance with Professor Guyot commenced after his arrival in America, when half of his life was already passed. In preparing this sketch of our late colleague I have therefore drawn largely from others, and chiefly from his family, and from a memorial address by Mr. Charles Faure, of Geneva, one of his pupils, which was published in 1884 by the Geographical Society of Geneva.†

*Youth—Education in Switzerland and Germany, 1807 to 1835.*—To obtain a clear insight into the character of Professor Guyot it is important to have in view, at the outset, the fact that the Guyot family, early in the sixteenth century, became Protestants through the preaching of the French reformer, Farel, the cotemporary of Luther; and also the sequel to this fact, that at the revocation of the edict of Nantes, the Guyot family was one of the sixty that moved into the principality of Neuchâtel and Valangin from the valleys of Pragela and Queyras in the high Alps of Dauphiny. Thus the race was one of earnestness and high purpose, of the kind and origin that contributed largely to the foundations of the American Republic.

\* Read before the National Academy of Sciences, April 21, 1886. (Biographical Memoirs, vol. II, pp. 309–347.)

† A. Agassiz, *Amer. Jour. Sci.*, 3d ser., xx, 254, 1880.

‡ *Vie et Travaux d'Arnold Guyot, 1807–1884*, par Charles Faure, 72 pp., 8vo. Read before the Geographical Society of Geneva, April 25 and August 25, 1884.



Professor Guyot's father, David Pierre, esteemed for his "prompt intelligence and perfect integrity," married, in 1796, Mademoiselle Constance Favarger, of Neuchâtel, "a lady of great personal beauty and rare nobility of character." Arnold Henri, one of twelve children, was born at Boudevilliers on the 28th of September, 1807, and was named after the Swiss patriot of the fourteenth century, Arnold von Winkelried. About 1818 the family moved to Hauterive, 3 miles from Neuchâtel, where his father died the following year. From the house at Hauterive young Guyot had before him, to the southeastward, the whole chain of the Alps from Mt. Blanc to Titlis; and his sensitive nature must have drawn inspiration from the glorious view—the same deep draughts that he attributed to young Agassiz in his academic memoir of his friend, with reference to the same circumstance—the snowy Bernese Oberland, the Jungfrau, the Schreckhorn, the Finsteraarhorn, the Eigers, and other summits to Mt. Blanc, "looming up before his eyes in the view from his house." Such views are calculated to make physical geographers and geologists of active minds. Guyot early found pleasure in the collection of insects and plants, and evinced in this and other ways the impress that nature was making upon him.

Previous to the year 1818, and for a while after, Guyot was at school at La Chaux-de-Fonds, a noted village "at the foot of a narrow and savage gorge of the Jura," 3,070 feet above the sea. In 1821, then fourteen years of age, he entered the College of Neuchâtel, where he was a classmate of Leo Lesquereux, the botanist. "Guyot and I," says Lesquereux, "were, for some years, brothers in study, working in common and often spending our vacations together, either at Guyot's home, at Hauterive, or with my parents at Fleurier; and I owe much in life to the good influences of this friendship." His studies were classical, Latin, Greek, and philosophy, arranged for preparing a boy for the profession of the law, medicine, or theology, with almost nothing to foster his love of nature.

In 1825, then eighteen, he left home to complete his education in Germany. After spending three months at Metzingen, near Stuttgart, in the study of the German language, he went to Carlsruhe, where he became an inmate of the family of Mr. Braun, a man of wealth and scientific tastes, the father of the distinguished botanist and philosopher, Alexander Braun, the discoverer of phyllotaxis—terms of intimacy with the family on the part of several of his relatives having been of long standing. The family comprised also a younger son and two daughters. Agassiz was then a student at Heidelberg along with young Alexander Braun and Carl Schimper, but he spent his summer vacations at the Carlsruhe mansion. A vacation soon came. "The arrival of the eldest son of the house," says Guyot, "already distinguished by scientific publications, with his three university friends—Agassiz, Schimper, the gifted co-laborer of Braun in the discovery of phyllotaxis, and Imhoff, of Bâle, the future author of one of the best

Entomological Faunas of Switzerland and Southern Germany—was a stirring event, which threw new life into the quiet circle. After a short time devoted to a mutual acquaintance, every one began to work. The acquisition of knowledge was the rule of the day, and social enjoyment the sweet condiment to more solid food." "My remembrance," remarks Guyot, "of those few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days." "Add to these attractions the charm of the society of a few select and intimate friends, professors, clergymen, and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof." "Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing season. Botany and entomology had their turn," and "demonstrations of phyllotaxis," he says, "now reduced to definite formula by Braun and Schimper, and shown in various plant forms, but especially in pine-cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct paleontological forms was the theme of animated discussions." He adds, "It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued and subsequently performed his lifework."\*

Guyot took in, equally with Agassiz, the newly developed views in botany, embryology, and zoological classification that were the subjects of thought and discussion, and became profoundly impressed thereby, as his later work shows.

From Carlsruhe, Guyot went to Stuttgart and took the course at the gymnasium, where he made himself a proficient in the German language. Returning to Neuchâtel in 1827, and there quickened in his religious faith and feelings by the preaching of the Rev. Samuel Petit-pierre, his benevolent impulses, under a sense of duty, led him to turn from science to theology and commence serious preparation for the ministry. In 1829, then twenty-two years of age, having this purpose still in view, he went to Berlin to attend the lectures of Schleiermacher, Neander, and Hengstenberg, and there remained for five years—1830 to 1835. In order to meet his expenses he accepted the invitation of Herr Müller, privy counselor to the King of Prussia, to live with him and give his children the benefit of conversation in French. The position brought him into intercourse with the highest of Berlin society, and was in many ways of great benefit to him.

While pursuing theology in earnest, his hours of recreation found

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\* Guyot's Academic Memoir of Agassiz, read April, 1878. (Biographical Memoirs, vol. II, pp. 44-47.

him making collections of the plants and shells of the country, and otherwise following his scientific leadings. Humboldt introduced him to the Berlin Botanical Garden, where the plants of the tropics were a source of special gratification and profit. Moreover, other courses of lectures attracted him, as those of Hegel, of Steffens, on psychology and the philosophy of nature, Mitscherlich on chemistry, Hofmann on geology, Dove on physics and meteorology, and especially those of Carl Ritter, the eminent geographer, whose philosophical views were full of delight to his eager mind and touched a sympathetic cord. Under such influence he found his love for nature-science rapidly gaining possession of him, and, yielding finally to his mental demands and to his conscience, which would not permit him to enter the ministry with a divided purpose, he determined to drop theology and make science his chief pursuit.

Ritter, of all his Berlin teachers, made the profoundest impression on his course of thought; and his biographical sketch of him, presented to the American Geographical Society in 1860, four years after his death, exhibits the admiring affection of a pupil who was like Ritter in his profounder sentiments. A paragraph from the memoir will show the tenor of Ritter's geographical teaching and something of the mental affiliation between them. Guyot says (p. 48):

"Ritter, in the introduction to the 'Erdkunde,' declares that the fundamental idea which underlies all his work, and furnishes him a new principle for arranging the well-digested materials of the science of the globe, has its deep root in the domain of faith. This idea, he adds, was derived from an inward intuition, which gradually grew out of his life in nature and among men. It could not be, beforehand, sharply defined and limited, but would become fully manifested in the completion of the edifice itself. That noble edifice is now before us, and, unfinished though it be, it reveals the plan of the whole and allows us clearly to perceive that fundamental idea on which it rests. It is a strong faith that our globe, like the totality of creation, is a great organism, the work of an all-wise Divine Intelligence, an admirable structure, all the parts of which are purposely shaped and arranged and mutually dependent, and, like organs, fulfill, by the will of the Maker, specific functions which combine themselves into a common life. But for Ritter that organism of the globe comprises not nature only; it includes man, and, with man, the moral and intellectual life." "None before him perceived so clearly the hidden but strong ties which mutually bind man to nature—those close and fruitful relations between man and his dwelling place, between a continent and its inhabitants, between a country and the people which hold it as its share of the continent—those influences which stamp the races and nations each with a character of their own, never to be effaced during the long period of their existence." We have here ideas that took, in Guyot, a still larger expansion.

Guyot derived great profit also from the works and the friendship of



Humboldt. His address at the Humboldt Commemoration of the American Geographical Society, in 1859, was a beautiful tribute to this model student of nature.\*

The five years of study at the Berlin University terminated with an examination which brought him the degree of Doctor of Philosophy. His graduating thesis, written in Latin, as was then the rule, was on "The Natural Classification of Lakes."

*To Paris, the Pyrenees, Italy, etc., 1835 to 1839.*—From Berlin, Guyot, in his twenty-eighth year—June of 1835—went to Paris to take charge of the education of the sons of Count de Pourtalès-Gorgier, and continued with the family four years. Letters of introduction from Humboldt led to much intercourse with Brongniart and other savants of the great city. For the summer he accompanied the family to Eaux Bonnes, in the Pyrenees. While there he made ascents of the higher peaks and took excursions in various directions—to the amphitheater of Gavarnie, to the borders of Spain by the Pont d'Espagne and the pass beyond, to the valley of the Eaux Chaudes, etc.—in order to study the features and flora, and compare the mountains in these respects with the Alps. In the autumn he went with his pupils to Belgium, Holland, and the Rhine to study the characteristic features of these countries. The following year he visited Pisa, and there, besides enjoying the new scenes, made various barometrical measurements, determining the elevation of the observatory at Florence and of other points.

*Trip to the glaciers in 1838.*—In the spring of 1838 Agassiz found Guyot still at Paris. During the summer preceding Agassiz had startled the scientific world by his declarations as to a *Universal Glacial Era*, contained in a paper read before the Helvetic Society of Natural Sciences assembled at Neuchâtel. His work in 1837—prompted in 1836 by Charpentier's discoveries proving the fact of a former epoch of immense glaciers in Switzerland—had led him to the bold conclusion, and he was full of his new idea when he met his old companion. He urged Guyot, who hesitated at accepting his views without examination, to study the facts, and obtained the promise that he would visit the glaciers that summer.

In his memoir of Agassiz, Guyot states that his six weeks of investigation that season in the Central Alps (nearly two years before Agassiz commenced his investigation on the Glacier of the Aar) were fruitful beyond expectation. He says that from the examination of the glaciers of the Aar, Rhone, Gries, Brenva, and others, he learned (1) the law of the moraines; (2) that of the more rapid flow of the center of the glacier than the sides; (3) that of the more rapid flow of the top than the bottom; (4) that of the laminated or ribboned structure ("blue bands"); and (5) that of the movement of the glacier by a gradual molecular displacement, instead of by a sliding of the ice-mass, as held by de Saussure.

\* Journal of the American Geographical Society, October, 1859; vol. I, p. 242.



The facts and conclusions were communicated to the Geological Society of France at a meeting at Porrentruy, in September, 1838. The communication is mentioned in the bulletin of the society for that year,\* but no report of it is given because the manuscript remained in his hands unfinished, in consequence of his protracted illness the winter following. The portion then finished (which was withheld from publication because, by special arrangement between them, Agassiz in 1840 entered upon the special study of the glaciers, and Guyot on that of the Swiss erratic phenomena, for their separate parts of a general survey) has recently been printed in volume XIII (1883) of the Bulletin of the Neuchâtel Society of Natural Sciences. In 1842 this manuscript was deposited, by motion of Agassiz, in the archives of the Neuchâtel Society, and in 1848 it was withdrawn by Guyot when he left for America. It is to be regretted that publication was not substituted in 1842 for burial. Its recent publication was made by the request of Guyot, early in 1883, from a certified copy of the original manuscript.

This paper gives the facts on which Guyot based his conclusions, and since these conclusions comprise some of the most important of the views now accepted relating to glacial motion and structure, and antedate the observations of Agassiz, Rendu, and Forbes, they have special interest.

The fact of *a less rapid movement of the bottom ice than the top, owing to friction*, he ascertained by the observation that in glaciers of steep descent, like the Rhone at its rapids, and the Gries, the transverse crevasses and the masses they cut off are at first vertical or nearly so; but below the rapids, where the slope is gentle and the crevasses become mostly closed, the masses are inclined with the pitch up stream, and this up-stream inclination is reduced at the termination of the glacier to a few degrees. The crevasses, although closing up below, are still traceable. He says the so-called layers are not strictly layers; but great numbers of cracks remain, which give to the mass the appearance of being made up of beds several yards thick, as may be seen in the glaciers of the Grindelwald valley, Aar, and others.

Further: To this pitch in the stratification at the lower extremity, the beds rising outward, Guyot attributes also the origin of the majestic ice-chambers, whence in most cases flow great streams, as that of the Rhone, of the Arveyron at the foot of the Mer de Glace, of the Lütschinen from the glaciers of Grindelwald.

The *more rapid movement of the center than the sides* also was learned from the Rhone glacier and others of steep descent. The crevasses, at first transverse, were found to be arched in front below the rapids, and increasingly arched to the extremity, and the successive crevasse-lines were very nearly concentric with the semicircular outline of

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\* Vol. ix, p. 407.

the extremity of the glacier. He gives a figure of the Rhone glacier as seen from the Maïenwand in illustration, and other later glacialists have appealed to the same evidence of lateral friction.

The semicircular outline of the terminal moraine was found to be another result of the cause just mentioned; and so also the "even-tail" arrangement of the several moraines immediately above the termination. The greater height and breadth of the central moraine is made a consequence of the greater velocity of the ice at the middle of the upper surface, more transportation taking place consequently in a given time.

Again: The conclusion that *the movement of the glacier was largely through molecular displacement* was supported by his observation that the ice, instead of breaking up and rising into an accumulation of masses on its passage by an isolated rock, or rocky islet, in its course, spread around and enveloped it without fracturing; and he refers to a fine example of this at the two isolated islets of rock in the midst of the great Brenva glacier, called the "eyes of the glacier." The same thing is observed "at the Jardin du Talèfre, a true islet in the midst of a *mer de glace*, having a border of blocks of rock, or of a moraine, cast upon its sides by the march of the glacier, just like the coast dunes of an island in the ocean."

In view of such facts, Guyot observes: "If it is true that the different parts of a glacier move with different velocities; if the glacier adapts itself to the form of a valley and fills all depressions without ceasing to be continuous; if it can bend around an obstacle and closely inclose it without the fracturing of its mass, like a spreading liquid, we may affirm that the movements take place through a molecular displacement, and we must abandon, at least as the only cause, the idea of a slow sliding of the mass upon itself as incompatible with the phenomena presented."\*

The "blue bands" of the glacier were first described by Guyot. He called the structure stratification, and observed it in the ice of the summit of the glacier of Gries, at a height of about 7,500 feet. A peculiar furrowing of the surface of the ice, the furrows 1 or 2 inches broad, attracted his attention; and this result of weathering he found to have come from the unequal firmness of the layers constituting it, layers of a softer "snowy ice" alternating with those of firm bluish glassy ice. The stratification was found by him to extend over hundreds of square meters, and downward, on the sides of crevasses, 20 to 30 feet deep, or as far down as the eye could penetrate; and it was evident that "the layers of the two sides of a crevasse were once continuous, like the

\* In French his words of 1838 are: "On peut affirmer que ces mouvements ne peuvent avoir lieu qu'en vertu d'un déplacement moléculaire, et il faut abandonner, au moins comme cause unique, l'idée d'un glissement lent de la masse sur elle-même, comme incompatible avec les phénomènes que présente la marche des glaciers."

strata of the opposite sides of a tranverse valley." He compared the stratification to that of certain coarsely schistose limestones.\*

He remarks, in conclusion: "We should say that the layers were not annual layers, but rather a series made day by day from small successive snow-falls that were melted in part by the sun of the day, and covered each night by the thick frost-glazing which envelops all the snowy summits of the high Alps."†

He further observes that "these beds were evidently formed at a greater height and in a different position from that where observed." He adds, in closing his remarks on the subject: "Do the beds, at first horizontal, or at least parallel to the surface of the glacier, accomplish, during its movement, evolutions, as yet imperfectly understood, analogous to those before mentioned [that is, those occasioned by differences in velocity of the middle, sides, and bottom, owing to unequal friction]. This is a point which should have further examination, with observations as minute, numerous, and universal as possible. Unfortunately a thick fog and threatening weather forced me to stop work before I had ascertained whether this structure was general for the whole mass of the glacier at that altitude, or whether restricted to that locality notwithstanding the proof of so large an extension of it."

Guyot had some confidence in his conclusions, but he also felt, as he states, the importance of more detailed investigation in order to decide on their real value.

On the 1st of December, 1841, Guyot communicated the results of his observations of 1838, so far as relates to the "blue bands," at a meeting of the Neuchâtel Society of Natural Sciences, "reading some passages from his note written in 1838." This communication contains the additional fact that the layers of the stratification in the Gries glacier were inclined about 45 degrees, were nearly transverse to the principal glacier, and appeared also to have sinuosities due to lateral compression.‡

Agassiz, in his *Système Glaciare* (1847), cites from Guyot's manuscript (then deposited with the Neuchâtel Society) the part relating to the "blue bands" (the only part he ever cited), and in this citation there is a paragraph on the inclination or pitch of the layers, with Guyot's additional suggestion that the pitch of the layers looked as if a result

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\* His words are: "Stratifié à la façon de certains calcaires grossièrement schisteux," and he explains it himself as implying a lamellar structure.

† In the original, the words are: "On aurait dit, non pas des couches annuelles, mais une série de couches plutôt journalières de neige tombée successivement par petites quantités, puis fondue en partie par le soleil de la journée, et couverte chaque nuit de cet épais verglas qui, au-dessus de la région des glaces, recouvre toutes les sommités neigeuses des hautes Alpes."

‡ The report of the meeting of the Neuchâtel Society is contained in the *Verhandlungen* of the "Schweiz. Nat. Gesellschaft," Altdorf, 1842. The abstract of Guyot's communication there given (pp. 199-200) says: "La position de ces couches était inclinée d'environ 45° dans le sens de la pente générale du glacier. Leur direction semblait presque transversale à celle du glacier principal, mais longitudinale à celle de son penchant méridional. Elle présentait quelquefois des sinuosités qui semblaient un effet de compression laterale."



of the advance of the surface portion over that below, a point already explained by him [by reference to friction at bottom].\*

Guyot opens his account of the blue bands with the remark that, as he had seen them only on one occasion, he dares not hazard an explanation; but his later sentences show that he was inclined to regard them as a result of deposition, and to consider the varying inclinations in the layers as due to subsequent disturbing action—that is, to the irregularities of glacier movement, caused by friction and pressure under the varying conditions of the glacier valley as to form and size.

Whether right or wrong in these suggestions as to the bands, Guyot's six weeks' work in the summer of 1838 was indeed fruitful. He had the satisfaction of seeing his conclusions for the most part confirmed by the facts collected by Agassiz, Forbes, and others, but not of receiving credit for his work and original conclusions, except on one point, and chiefly because of the want of proper publication.†

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\* The cited paragraph in the *Système Glaciaire* (p. 209) is as follows: "La direction de ces couches coupait à angle droit la ligne de marche (de pente) du glacier, leur inclination déviait de  $30^{\circ}$  à  $40^{\circ}$  de la perpendiculaire vers la partie inférieure, comme si la pente superficielle gagnait de l'avance sur la partie inférieure ainsi que je l'ai décrit plus haut." The writer learns from Mrs. Arnold Guyot that this paragraph is a part of the original manuscript, and that it was by oversight that it was not sent to the Neuchâtel Society in 1883 with the rest.

† Rendu's "*Théorie des Glaciers de la Savoie*" was published in 1841 (*Mem. Soc. Roy. Savoie, Chambéry*, vol. x). Forbes's first letter from the Alps, announcing his discovery in August, 1841, of the "blue bands" in the Aar Glacier, was communicated to the Royal Society of Edinburgh, December 6, 1841, and published in January in Jameson's *N. Phil. J.*, vol. xxxii, 1-42. Agassiz's first work on glaciers, "*Etudes sur les Glaciers*," was published in 1840. Neither of these publications mentioned Guyot or his observations.

Guyot's communication of 1841, published in the *Altdorf Verhandlungen*, was drawn out by a discussion between Forbes and Agassiz relating to priority as to observations on the blue bands, and it was made just five days before Forbes's first letter was read in Edinburgh. Agassiz claimed credit for Guyot at the meeting in 1841, as a set-off against Forbes's claim, and again, in the *N. Phil. Journ.*, xxxiii, 265, 1842. Forbes, in the following volume of that journal, xxxiv, 145, 1843, gives Guyot credit for original discovery as regards the "blue bands," and speaks of his corresponding with him on the subject; and he repeats the acknowledgement to the "ingenious professor of Neuchâtel," in his *Travels through the Alps of Savoy*, 1843 (first edition) and 1845 (second edition), page 28. Desor, in the same journal, xxxv, 308, 1843, in a paper on Agassiz's recent glacier researches, introduces a translation of Guyot's account of the banded structure, but cuts it short at the words, "opposite sides of a transverse valley," leaving off the explanatory remarks which follow.

Tyndall, in his "*Forms of Water*" (1872, page 183), gives Guyot credit for priority; and he cites, both in this work and in his earlier "*Glaciers of the Alps*" (1856), a translation of Guyot's account, ending it a sentence short of Desor's citation, with the words, "certain calcareous slates" in place of Guyot's "certain schistose limestones"; and on page 187 of "*The Forms of Water*," knowing only a part of what Guyot had written, he does him more than justice (admitting Tyndall's view to be established) in saying that he "threw out an exceedingly sagacious hint when he compared the veined structure to the cleavage of slate rocks," for the comparison in Guyot's paper implies rather stratification from deposition.

The first detailed comparison of the "blue bands" to slaty cleavage in structure,



Having attended at Berlin the lectures of Dove on physics and meteorology and those of Ritter on physical geography, Guyot knew when he went to the mountains what to look for in case the glaciers were great flowing streams of ice, as had often been supposed; he knew that the flow of a stream is retarded along the sides and bottom by friction, and he naturally looked also for something in the encounter of the glacier with rocks answering to molecular displacement. Hence, in his six weeks of observations on the glaciers, he reached, without waste of time, good conclusions—the conclusions of a physical geographer. His investigation did not enable him to appreciate the interior fracturing that works along with molecular displacement in the flow of the ice, but his conclusion was still far in the right direction and decisive against the hypothesis he opposed. That he did not continue his study of the glaciers to thoroughly established results was owing to his yielding the subject afterward to Agassiz. Fidelity to his friend and his volunteered agreement curbed in and silenced him; and so his paper, excepting the paragraphs on the “blue bands,” remained buried until after Agassiz’s decease.

*At Neuchâtel, Professor in the Academy, 1839 to 1848.*—In 1839, at the age of thirty-two, Guyot left Paris and returned to his native town. He became at once an active member of the Society of the Natural Sciences (which had been initiated by Agassiz in 1832), and was made by the Society one of a committee—including also M. d’Osterwald, and H. Ladame—for the organization of a system of meteorological observations in Switzerland and the selection of the best instruments for the purpose. On the establishment of the “Academy” at Neuchâtel, for the purpose of furnishing a university education to the graduates of the college or gymnasium, he was appointed to the chair of history and physical geography, and became a colleague of Agassiz. He hesitated about taking charge of the department of history, as this had not been one of his special lines of study; yet, once committed to it, he plunged into the subject with great earnestness. He says he groped on among the details for two years before he began to distinguish its grand periods, and the light as it broke in upon him caused so intense excitement that he was made ill.

Instruction was a great pleasure to him, because of his deep interest both in his subject and in his pupils. His two departments called out from him thirteen general and special courses of lectures. With regard to the lectures, Mr. Faure says: “From the first, in spite of his apprehensions, he captivated his audience by his easy, elegant, sympathetic words, by the breadth of his views, and the abundance and happy arrangement of his facts. He had, each winter afterward, the pleasure

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position, and origin appears to have been made by Prof. Henry D. Rogers at the Cambridge meeting of the American Association in 1849 (*Proc. Am. Assoc.*, II, 181). But Rogers attributed the structure in both to conditions of temperature and not, like Tyndall, to pressure.

of seeing men of cultivation of all classes in Neuchâtel pressing into the large hall of the college and listening to him with riveted attention." His pupil adds: "What zeal he inspired! what ardor for work! The fire with which he was filled passed to us. He was more than a professor; he was a devoted friend, a wise counselor, associating himself with us and encouraging us in our work."

Guyot, besides lecturing and instructing, did all he could of outside work—meteorological, barometric, hydrographic, orographic, and glacialistic. The hydrographic work was the careful sounding of Lake Neuchâtel (in all eleven hundred soundings) as the commencement of a study of the annual variation in the temperature of the waters of the Swiss lakes. His chief research—that on the distribution of the boulders or erratics over Switzerland—occupied him, "single-handed, seven laborious summers, from 1840 to 1847," he allowing himself only, "at the end of his working season, the pleasure of a visit of a few days to the lively band of friends established on the Glacier of the Aar, in order to learn the results of their doings and communicate his own to them."\* Switzerland in the ice period was his subject; and the sources of the boulders and the courses of ice transportation were the chief inquiries. The investigation involved excursions on foot and careful examination of the whole range of the Swiss Alps, the slopes into Italy, the plains of Switzerland, and the mountains on the northern and western borders, including the Juras—in all an area of 190 by 310 miles—in order to trace the erratics to their high sources among the snowy summits, examine the rocks of all peaks, ridges, and valleys for comparison with those of the erratics, measure the heights along the lines and limits of the erratics from plain to mountain peak, and note all glacial markings. The task was accomplished with the greatest possible fidelity; "thousands of barometric measurements" were made in the course of it, and between five and six thousand specimens were gathered in duplicate.

Thus, says Guyot, "Eight erratic basins were recognized on the northern slope of the Alps—those of the Isère, the Arve, Rhone, Aar, Reuss, Limmat, Sentis, and Rhine; and four on the southern slope—that of the Adda, including Lake Como, of Lugano, of Ticino, including L. Maggiore, and that of the Val d'Aosta.

"Moreover, a question left hitherto untouched—the distribution in each basin of the rocks special to it—was minutely examined, and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines. This identity, and the absolute continuity of the erratic phenomena from the heart of the Alps down the valleys and beyond to the Jura left no alternative but to admit the ancient existence of mighty glaciers as vast as the erratic regions themselves, and having a thickness of over 2,000 feet."

Brief notes on his work were published in the *Bulletin of the Neuchâtel*

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\*Memoir of Agassiz. (Biographical Memoirs, II, p. 67.)

Society of the Natural Sciences for November, 1843, May and December, 1845, and January, 1847.\*

Guyot reserved the complete report for the second volume of Agassiz's great work on glaciers. But, unfortunately, after the first volume by Agassiz appeared at Paris, in 1847, there came the revolution of 1848, which put an end to their plans.

The study of the geological structure of the Jura Mountains, in which he worked out the system in the flexures of the strata and proved that it must have been produced by lateral pressure, was another of Guyot's labors soon after his return from Neuchâtel, although not reported on until 1849, at the Cambridge meeting of the American Association.†

Guyot had been teaching at Neuchâtel nine years when suddenly the "Academy" was suppressed by the grand revolutionary council of Geneva of 1848. The 13th of June brought the tidings, and on the 30th the end came "without any indemnity to the professors." Letters from Agassiz urged him to come to America. Though reluctant to take the step because of the many ties of friendship and association that bound him to Switzerland, and especially on account of the family under his charge, consisting of his mother, then seventy years old, and two sisters, which he should have to leave behind, he had the decision of his mother, after her careful reading of Agassiz's letter, in favor of it,‡ and in the following August he left friends, home, and Europe.

*In America.—The Lowell Lectures at Boston—"Earth and Man"—*1848, 1849.—Without English speech, with no plans ahead, and with more than forty years of his life behind, a crowd of apprehensions continued to haunt Guyot until he reached the American shores. Once landed in New York, he was soon after at Cambridge with his friend Agassiz; and from that time the calamity that had befallen him, commenced to prove itself a blessing. It was for him, falling in with the "geographical march of history," and coming to the land and "people of the future," where no political or religious shackles were in the way of success, and where an audience as wide as the continent was ready for whatever he had to communicate.

In September, a fortnight after his arrival, Agassiz took Guyot to the meeting of the American Association at Philadelphia. At its close he made his first journey to the Alleghanies, spending a week in crossing

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\* The facts are well presented also, though briefly, in the second volume of D'Archiac's *Histoire des Progrès de la Géologie*, pp. 259-265.

† Proc. Amer. Assoc. II, 115, 1850.

‡ August 8th, 1848, the day of his departure from Neuchâtel, he writes: "Ma mère a été toujours si forte et si confiante qu'elle m'a soutenu jusqu'au dernier moment, mais son dernier sanglot, en me quittant, m'est allé au cœur: Oh! que Dieu me donne de la revoir et d'embellir ses derniers jours." This desire was realized. In the autumn of 1849 he had the happiness of welcoming his mother, two sisters, and a niece to the new home which he had prepared for them in Cambridge.



the region in Pennsylvania to Bedford and Cumberland. On his return he stopped in Princeton to deliver a letter of introduction to Dr. Charles Hodge, and found there friends who later welcomed him as a colleague.

Returning to Cambridge, he was soon afterward invited by Mr. Lowell to deliver one of the winter courses of lectures at the Lowell Institute, and in January he resumed in Boston his academic work, taking for his subject Comparative Physical Geography. He spoke in French, almost without notes, to a large and appreciative audience, and from that time the Swiss professor had an American reputation. These lectures, written out after the delivery of each, were translated by Professor Felton "with rare kindness and a disinterestedness still more rare," says Guyot,\* and published under the title—now familiar—of "Earth and Man."

The views of Ritter, which had put life and humanity into geography, are used by the author as the basis of still wider generalizations bearing on the earth and human history. Guyot first draws out in admirable style the distinctive physiographic features of the continents and seas, and then proceeds to consider the *physiology* of the continental forms, by which he meant the interactions of the continents in their own history, and in that of man as their tenant. Having finished the physiographic portraiture in the first seventy pages, he says: "We must now see these great organs in operation; we must see them in life, acting and reacting upon each other," that is, "their physiological phenomena."

In order to exhibit the "living" action between these "organs" in its true relations, he first explains the fundamental law of progress in all growth or development; then exhibits the application of the law to the earth in its genesis, and in its later progress through the ages, and finally draws out and puts into order the grander facts in the conditions of the earth connected with the development of man in his social, political, and moral relations.

Guyot makes all historical progress a *development*, carried forward through the incessant action and reaction of differences or unlike conditions; he speaks of it as a gradual specialization of parts and functions, comparable to the progress in germ development and having the same general formula; as beginning in a homogeneous unit, which has real but unmarked differences of parts, advancing through various changes and individualizations, and ending in the complex "harmonic unit." He finds the law exemplified in the development of the earth after the nebular theory of La Place; in the slow progress of the earth's continents from the condition of scattered islands in a large, shallow sea to that of united distinctively featured lands; in the progress of the earth's life, as made known by geology; the progress in the development of the races of men, and in the origin of human societies.

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\* In the dedication of "Earth and Man" to Professor Felton.



The three phases recognized in the process are that of undistinguishable parts, germ-like; that of diversification; that of unity, which "allows all differences, all individualities, to exist, but co-ordinates and subjects them to a superior aim." Further, the final product or "harmonic unit," be it an organic species, or a continent, or societies, or whatever condition, has its purpose fulfilled not in existing, but in preparing for and producing other development beyond.

As differentiation goes forward increasing differences, inter-actions become more energetic. The greater the variety of individualities and relations in a society of individuals the greater also is the sum of life, the more universal, more complete, and more elevated the development.

Further, besides the unfolding of life "in all its richness of kinds and forms by diversity, there is involved an exhibition of it in its utility, in its beauty, in its goodness, by harmony; and this also for the entire globe, collectively considered as a single individual." This last point was the special subject of the larger part of his lectures.

Here was development for all history. All was put under one formula, that which is expressed in embryonic development, and was illustrated by details sustaining the application of the law.

With regard to the geological succession of life, he had learned, from Agassiz's announcements in his "*Poissons Fossiles*" (the first volume, published in 1834), that the geological succession in species was analogous in many respects to embryonic succession,\* and he had gathered other ideas from the philosophical thoughts of Goethe and Steffens, as well as Ritter; but in his special application of the principle to the earth's early and later history, and to human progress, he went beyond his teachers.

In reply to an inquiry as to the originality of his views, he wrote me, December 6, 1856, as follows:

"The principle at the basis of development is at the bottom of all the modern philosophy of Germany, especially the philosophy of nature, but in what an abstract and indigestible form will be seen on opening any one of their uninviting volumes. Goethe, the poet and philosopher, has, in a more concrete and tangible form, the beautiful law that the more homogeneous, the lower the organism, and the more diversified in its parts, the higher the grade. Steffens, of Berlin, acted more directly on my mind, and from him I got a distinct view of the importance of the internal contrasts and differences as regards the process of life." - - - "All these notions of the law were taken, as was natural, from the organized being; I do not recollect to have seen it applied, as I have applied it, to inorganic nature; to astronomy; to geology—I mean to the growth of continents, and to the successive and increasing diversifications of the surface keeping pace with the wants of an increasing development of life; to physical geography, in

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\* Quoted by Guyot in his sketch of Agassiz, p. 57.

which the law of *internal contrasts*, as conditions of a more active life, plays so great a part. Hence the whole scheme of that part of earth and man. This law thus became for me the key for the appreciation and understanding and grouping of an immense number of phenomena both in nature and history. My views of the human races and of universal history are, in great part, on the same base. So also the idea of the true sense of the first chapter of Genesis as a characteristic of the great organic epochs."

His recognition of the same principle in organic nature is expressed as follows in a letter of March 17, 1856, referring in the first paragraph to the view of Agassiz that the sub-kingdoms among animals and the grander divisions among plants represent so many plans of structure:

"But do we not too much forget that even structure is but a means—the expression of a mode or function of life, which mode or function is the idea of it, and in one sense its cause? If so, then structures only express various aspects and functions of life, animal or vegetable, and they are related and connected together as the various aspects, modes, and functions of organic life are with the essential idea of life itself.

"Now, life is essentially (I mean phenomenally) growth, development, movement from phase to phase, from birth to death, and it seems to me that I can find no principle which gives me a more clear, natural, and connected idea of the innumerable types and forms of vegetables and animals than to consider them as typical of so many phases of life, whether of growth, or mode of life, or function of life."

Guyot endeavored to find the expression of the formula of development in the details of the systems of life, animal and vegetable, as exhibited in the progressive life of the globe as well as the existing species; and the preceding sentences in his letters were introductory to further explanations with regard to this system. His philosophical ideas were broad and deep enough to embrace the results of all discovery, although his illustrations manifested something of the limited knowledge of species and groups of thirty years since.

In 1862 he delivered a course of lectures at the Smithsonian Institution on this subject, or "The Unity of Plan in the Systems of Life, as exhibited in the Characteristic Ideas and Mutual Relations of the great groups of the Vegetable and Animal Kingdoms;" but, although publication was desired by the Institution and urged by others, the manuscript was never ready. Full stenographic reports were made, which he never found time to revise.

It is interesting to note, in both Agassiz and Guyot, this full faith in a system of development as the best and truest expression of the order of succession in the progress of life, and, in Guyot, the application of the principle to all progress, while, at the same time, neither doubted the constancy of species or the necessity of divine acts for originating species and carrying forward the development. Agassiz declares, in his "Poissons Fossiles:—" "More than fifteen hundred species of fossil fishes

with which I have become acquainted, say to me that the species do not pass gradually from one to the other, but appear and disappear suddenly, without direct relations with their predecessors." To each the system of progress was as orderly a system as that which evolutionists now recognize. The successional relations made known by paleontology were welcomed for the same reason as now—because they illustrated the true system of progress. The difference was not as to these relations, or the system of progress, but as to the means of carrying forward the development.

Guyot also gives a brief explanation of his views with regard to the *Geographical March of Human History*, and this is all he ever published of his historical course. In the expression "geographical march" he refers to the fact that human progress took place not by gradual elevation at one center of civilization, but by successive transfers from one nation or center to another. He points out and illustrates three stages in the progress:

First. The stage characteristic of the old Orient—that of *subjection*; subjection not only to the despotism of rulers and of society through castes, but also to that of nature's forces through fear and superstition, and to the despotism of priests, exerted over both people and rulers through the superstitious element, and to priests and rulers conjoined, making the subjection complete. It was "the subjection of human liberty to the yoke of nature," "to the immutable, blind laws of necessity, which regulate the courses of the celestial bodies and the life of nature;" to the "inflexible, unloving, inexorable gods of the early East."

Secondly. The stage of growth in *individual* freedom, worked out in and characterizing Greece—a land "neighboring still the East," but admirably organized by its very features, by the combination within it of all the contrasts of the continent for the development of individuality; a free people full of the energy of youth and the conscious strength of freemen, converting "the world of nature" into "that of the human soul," where "all the riches of poetry, of intellect, of reason, which are the heritage of the human mind, display themselves without obstacle and expand in the sun of liberty"; where "religion is a deification of the faculties and affections of man"; where "the forces of nature, the trees of the forests, the mountains, the springs, and the rivers appear as objects of worship," "under the form of gods, of goddesses, and of nymphs, endowed with all the affections and subject to all the weaknesses of common mortals."

But, he says, the Empire of Alexander, and of individuality, and of fratricidal wars was not for the future. The Greek principle wanted the addition of association, "a principle determined by nature and not by voluntary agreement."

Thirdly. The third stage was that of Rome, its center a little farther toward the west, which, through the spirit of *association*, became the great empire and law-giver for the world. But selfish and corrupt, "one-half



of the men slaves to the other half," "exacting only one worship, that of the emperor, who personifies the state," the Roman world, an aggregate of nations without a common faith, "perishes, like the rest, of its own vices."

At that time, when the principle of association under human enactments was proving itself a failure, and despair was settling over the people, then, says Guyot, "the meek form of the Saviour appeared upon the scene of the world," to "recall man to the only living God," and "proclaim the equal worth of every human soul," "the unity and brotherhood of human kind." "It was upon this new basis that humanity, recommencing its task, goes on to build a new edifice." The task was not committed to the corrupt Roman; the Roman Empire broke before the Germans from the North, and the center of civilization passed to the north of the Alps, and soon embraced all Europe. The new influences tended to harmonize the conflicting nationalities and bring about finally "a family of states so closely bound together that they are only members of the same body." And while liberty was thus gained for man, nature, as never before, opens herself to him and becomes his aid in all progress. Not only Europe, but, through her people, all the world receives the new light and commences to participate in the new progress.

But Europe and all the old nations, "through historical ties of every kind, ancient customs, acquired rights," encounter almost insurmountable difficulties in the way of adaptation to the exigencies of a new principle—that of "liberty, equality, and fraternity" rightly interpreted; and the carrying out of this work to reality demanded for its full development, as the law of history shows, that it should be transferred "to a new people;" transferred, as "the geographical march of civilization tells us, to a new continent west of the Old World—to America"—a land wonderfully adapted to this purpose by the simplicity and unity of its features, by its great plains and rivers, and by its commanding position between the oceans.

He says, in conclusion, referring to the historic nations: "Asia, Europe, and North America are the three grand stages of humanity in its march through the ages. Asia is the cradle where man passed his infancy under the authority of law, and where he learned his dependence upon a sovereign master. Europe is the school where his youth was trained; where he waxed in strength and knowledge, grew to manhood, and learned at once his liberty and his moral responsibility. America is the theater of his activity during the period of manhood, the land where he applies and practices all he has learned, brings into action all the forces he has acquired, and where he is still to learn that the entire development of his being and of his own happiness are only possible by willing obedience to the laws of his Maker."

When Carl Ritter received a copy of the work "Earth and Man" from his old pupil, he sent Guyot a letter of congratulations, with the



strongly underscored word, *excellent*, thrice repeated; and more than once he wrote him that the whole conception carried out in the volume was a marked progress. He also told Guyot that he had made the volume his *vade mecum* on a long summer journey.

The work has passed through several editions in Great Britain, and has been translated into German and Swedish; and a translation into French, by Mr. Faure, will be published this year in Paris.

Guyot's views put the earth's genesis or development, as a sentence cited from him shows, under his general formula for historical progress; and although the subject is not dwelt upon in his *Earth and Man*, a brief statement of his argument and conclusions is, therefore, in place here.

The subject came under his consideration at Neuchâtel, in 1840, while preparing a lecture for his course in Physical Geography. Looking only to the suggestions of science, under which the so-called nebular theory had in his mind a place, he made out a scheme of the successive stages in the earth's development. After its completion it "flashed" upon him that the succession arrived at was just that of the cosmogonic record in Genesis, and this led later to a critical comparison of the two. Harmonizing the Bible and science was, hence, far from his original purpose.

The succession in the scheme so derived was (as I learned it from him) as follows:

(1) The endowing of matter and space with forces, whence the beginning of its activity.

(2) The stage of specialization, or that of the subdividing of the original matter or nebula through the forces communicated, and thus the development of systems of spheres in space.

(3) The stage of the individualized worlds—the earth among them—and the commencing preparation of the earth for new developments pertaining to organic nature.

The events thus far are those of the inorganic part of the cosmogony. In the organic period there was:

(1) Life, manifested in the simpler kinds of plants. Next, animal or sentient life under simple forms—the Protozoans. These simple kinds of plants and animals represented the first or germ-like or homogeneous stage in the development of the system of life. He believed it to be probable that both existed before the close of Archæan time.

(2) The stage of specialization, or that of the development of plants and animals of higher and higher grade, under various types or subdivisions, based severally on different structural and physiological qualities.

(3) The stage of the synthetic or harmonic type. Among plants, that of the Dicotyledons, in which the different kinds of tissues in plants, and the stem, leaf, and flowers are for the first time harmoniously combined; and among animals, that of the vertebrates, in which the ner-

vous system has first its proper commanding position; and, lastly, among mammals, that of man, eminently the "harmonic unit" for the system of life, combining the highest of structural qualities and physiological characteristics under the most perfect harmonious development.

It is not surprising that after the conception of such a scheme he should have recognized a relation in it to the record in Genesis. Looking to this record, which announces the grand stages in a few brief sentences, he observed that the "fiat" of the first day, "Let light be," indicated, since light is a result of molecular action, the imparting of activity to matter as the first step in the development of the universe; that the dividing of the waters on the second day appeared to have its only befitting explanation in the subdividing or specialization of the primal nebula, as stated above; and that the fiat "Let the dry land appear," on the third day, indicated the defining of the earth and the preparation of it by the appearance of dry land for its new work. Thus he found the first three works in Genesis to correspond essentially with the first three in the scheme taught him by science. The following works, the creation (*a*) of plants, (*b*) of the invertebrates and inferior vertebrates, (*c*) of mammals—the remaining vertebrates, (*d*) of man, have in the record the order of their first appearance as made known by science. It has to be admitted that doubt at present exists as to the earliest birds having preceded the marsupial mammals, but none as to their long preceding ordinary mammals. Future discovery may place them before the marsupials. Remains of birds are the rarest of fossil vertebrates.

Guyot recognized also a still deeper concordance between Genesis and science, namely, that not only in the opening verses, but throughout the chapter, the idea of a system of development is taught. The fiat "Let light be" was the commencement of developments before the earth or other spheres had existence, not the creation of an entity. With regard to the earth, the first verse announces that it was formless, empty, waste, or, as the Septuagint translation describes it, "uncomposed and invisible." Then, on the third day, where the second mention comes in, the words are not Let the earth be, but "Let the dry land appear," implying that the specializing changes had gone forward eventuating in the earth and making it ready for further developments. The fiat creating plants was not Let plants be, but "Let the earth bring forth," which words imply development in some way; and a similar idea is to be derived from the fiats "Let the waters bring forth" for the invertebrates and lower vertebrates on the fifth day, and "Let the earth bring forth" for mammals on the sixth day.

Such a system of developments, which, after an initiating fiat, continued on their progress through the ages following, was not consistent with the idea that the days of Genesis were definite periods of time. It teaches that they simply mark the beginnings of new phases or new grand stages in the history of creation.

Guyot's critical eye further discovered that the two triads of days in the record—the first, the *inorganic*, including days one to three, the second, the *organic*, days four to six—have three parallel features which emphasize strongly this subdivision of the chapter, and indicate parallel stages in the developments: first, in each triad, the work of the first day was light; second, in each, the work of the last day comprised two great works; third, the second work of the last day in each triad was the introduction of an element that was to have its full development in the following era; in the first triad this element was life, plants being the second work and life having its chief display in the succeeding era; in the second triad it was spiritual life, that of man, a planting of the moral world in the material, for the exaltation of the latter in aim and character.

Guyot thus shows that the old document is philosophical in its arrangement, true to the principles of development in history, and essentially true in the order of its announcements, and that the best explanation which science is now able to give on the great subject of cosmogony is also that which best explains, in all its details, the first chapter of Genesis and does it justice.

I have said that Guyot, while adopting the law of development and applying it to all history, still believed that true species came into existence only by divine act. In his later years, as his work on "Creation" shows, he was led to accept, though with some reservation, the doctrine of evolution through natural causes. He excepted man, and also the first of animal life; for in the case of both, while science speaks undecidedly, the record in Genesis teaches, by the use of *bara* for create and by not using the word elsewhere subsequent to the first verse in the chapter, that actual creation was intended. He also held that there might be other exceptions; and he objected, moreover, on other grounds to the development of man through nature alone. Still, as always with Guyot, God's will was the working force of nature, and secondary causes simply expressions of it.

Guyot's views on Genesis, although dating from 1840, and presented by him since that time in occasional courses of lectures, were not published in detail until the last year and hours of his life. With the publication of the volume his work and life ended.\*

*Educational Work—1849 to 1884.*—I pass now to Guyot's work in America. His lectures at Boston were "a brief epitome of his teaching in Neuchâtel,"† and they were, therefore, a part of European Guyot. He now becomes, though European in equipment, an American in his labors.

His lectures had made him known as a geographer of the widest and

\* Creation, or the Biblical Cosmogony in the light of modern science. 136 pp., Svo., Scribner's Sons, New York, 1884. A short article by him appeared in 1873 in the report of the sixth conference of the Evangelical Alliance, New York.

† Letter to the writer of February 4, 1881.



most elevated kind. From Agassiz's home at Cambridge his acquaintance extended rapidly, and he was soon known also as a man of practical ideas with regard to school instruction in geography and in other subjects. It was at once accepted from him that the starting point in geographical education should be nature and not books; that teachers should take their pupils to the hills and show them the valleys and streams and mountains, and aid them in tracing out the general features, so that they might make themselves geographers of the region about them and lay a foundation for broader geographical study; that the study of the geography of nature should precede that of man and political geography; that maps showing in strong lines the reliefs, or the mountains and plains, and then those showing the river systems and other natural features, should come before those of States and towns. The idea commended itself that each country should be presented to the mind of the pupil by such groupings of prominent features, inanimate and animate, as would, so far as possible, re-produce the reality of nature; and that waters, lands, and climates should not merely be described, but also displayed in their mutual inter-actions and relations, and in their inter-actions with the living tribes of the waters and land, that thereby the activities of the earth and their varied consequences might be understood, and also the influences thence arising that bear on man and human history.

These views he had learned from his teacher, Carl Ritter, and the latter in part directly from Pestalozzi. They were so obviously good that they spread rapidly. Guyot was soon under appointment from the Massachusetts board of education, lecturing on geography and methods of instruction to the normal schools and teachers' institute; and this engagement took him to all parts of the State and gave him each year, for the six years he held the position, aggregate audiences of 1,500 to 1,800 teachers. His friend Agassiz, moreover, was associated with him in the work, giving a like and equally strong impulse to studies in natural history.

Guyot lived to see his methods of instruction become universal. He furthered this end by preparing, on his plan, between the years 1861 and 1875, a series of school geographies of different grades, six in number, ending in a school physical geography, and also a series of wall maps, physical, political, and classical, thirty in number, all of which passed into wide use.\* These books forced the old books and atlases to change about or succumb, and they led also to many imitations among book-makers.

His plan for the completion of the series in a general treatise on physical geography, unfortunately, was never carried out. His failure is to be attributed in part to the difficulty he felt in putting his ideas

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\* Guyot had a valuable aid in map-making in his nephew, Mr. E. Sandoz, who came to America with him, after having previously spent two years at Gotha with the geographer and publisher, Herr Petermann.



down in English. He writes in 1882 to his Swiss friend, M. F. Godet: \* "Quene donnerais-je pas pour avoir la facilité d'écrire et de dicter ! Mais cette malheureuse langue, qui n'est pas la mienne, est un obstacle toujours renaissant. La phrase m'entrave et me coûte dix fois plus que les idées." That Guyot understood the language well is evident from his memoirs of Ritter and Agassiz, and his tribute to Humboldt, as well as from his scientific papers.

Besides the geographical works already mentioned, Guyot was the author of the Treatise on Physical Geography in Johnson's Family Atlas of the World, and editor, with President Barnard, of Johnson's New Universal Encyclopedia, in which are several papers by him on geographical and other subjects. His school atlases and geographies received the medal of progress at the Vienna Exposition in 1873, and the gold medal, the highest honor awarded, at Paris in 1878.

In 1854 Guyot received an appointment to the professorship of Physical Geography and Geology at Princeton, then established for him on an endowment from one who had learned to admire him as a Christian philosopher, Mr. Daniel Price, of Newark, New Jersey,† and in 1855 he removed with his family from Cambridge to Princeton, where he found his tastes, his social instincts, his desires to impart ideas as well as acquire them, all fully gratified. To the duties of his professorship he permitted himself to add other educational work, becoming and continuing for several years lecturer on physical geography in the State normal school at Trenton, and from 1861 to 1866 lecturer extraordinary in the Princeton Theological Seminary, on the Connection of Revealed Religion and Physical and Ethnological Science, and also giving courses of lectures for a time in the Union Theological Seminary, New York, and in connection with a university course in Columbia College, New York. At the Smithsonian Institution he delivered a course of five lectures in 1853 on the Harmonies of Nature and History, and in 1862 six lectures on the Unity of Plan in the System of Life, as previously mentioned.

Besides class instruction at Princeton, Guyot did important work for the college in the establishment of a museum. He found nothing there of the kind, but by effort at home and while on a trip to Europe, and with the aid of students inspired by him, and the generosity of friends, the museum became, under his care, rich both paleontologically and ethnographically, and in foreign as well as American specimens. It derives special interest, moreover, from possessing, through his gift, the five thousand rock specimens collected in his study of the erratic phenomena of the Alps which he brought with him to the country. The specimens are so displayed in cases that, in connection with maps in the room, they teach "the extent, thickness, limits, and courses of the

\* Mr. Faure's biographical sketch, p. 39.

† With the consent of Mr. Price, this chair was subsequently fully endowed by and named for Mr. John J. Blair, of New Jersey.

great ice-mass that once covered all Switzerland." Guyot, besides, found much gratification in the successful work of his pupils in Rocky Mountain exploration and the large additions to the collections thus secured. The memoir of Guyot, by William Libbey, jr., vice-director of the museum, speaks of the museum as the most substantial monument that Professor Guyot has left behind him in Princeton.

*Meteorological and Geographic Work, 1849 to 1881.*—At the Philadelphia meeting of the American Association in 1848, where Guyot went with Agassiz soon after reaching the country, he met Professor Henry, of the Smithsonian Institution, and this meeting was soon followed by the perfecting of plans for a national system of meteorological observations. Guyot was charged by Professor Henry with the selection and ordering of the improved instruments that were required; and among his changes he rejected the old barometers in favor of the cistern barometer of Fortin as improved by Ernst and further improved in accordance with his own suggestion as regards safety of transportation, making what is now the Smithsonian barometer. He also prepared directions for meteorological observations, which were published by the Institution as a pamphlet of forty pages in 1850, and a volume of meteorological and physical tables, which was printed and distributed in 1852. The latter very important work was afterward enlarged and became, in the edition of 1859, a volume of 634 pages, containing over 200 tables admirably arranged and adapted for the best meteorological and hypsometric work.\* A letter of his to Professor Henry in 1858 says that two-fifths of the pages of tables, representing 68,000 computed results, were wholly new and were prepared for the volume. He adds: "It is essentially a work of patience, in doing which the idea of saving much labor to others and facilitating scientific research is the only encouraging element."

One important part of Guyot's meteorological labors consisted in the selection and establishment of meteorological stations. With this object in view, he made in 1849 and 1850, under the direction of the regents of the University of New York, in conjunction with the Smithsonian Institution, a general orographic study of the State of New York in order to ascertain the best locations for such stations. Thirty-eight stations were then located by him at points widely distributed over the State; and, at the same time, patient, earnest Guyot took pains to instruct observers at the stations in the use of the meteorological instruments. Similar work was also done under like auspices in the State of Massachusetts. The report of the regents of the University of New York for 1851 contains the topographical results of the exploration, giving an excellent sketch of the high plateaus and the larger valleys of the State.† The exploration in 1849 extended into the depth of

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\* The volume of tables is No. 538 of the Smithsonian Publications. In 1859 it received from its author a further addition to its tables of 70 pages, and in 1884 a new and enlarged edition, in preparation since 1879, was issued; forming vol. XXVIII, of the "Smithsonian Miscellaneous Collections."

† Reprinted in the American Journal of Science, second series, XIII, 272, 1852.

winter, and his long journeys in that inclement season were often over unbroken roads and in the roughest of conveyances.

Thus Guyot went almost immediately to work in his favorite fields, laying the foundations not only for geographical education, but also for geographical investigation, and for a national system of meteorological observations and records. The national plan was not then inaugurated; but the work thus carried forward under the Smithsonian Institution was the initiator, in fact, of the United States Signal Service Bureau.

In the summer of 1861 Guyot had occasion to visit Europe, and he took advantage of the opportunity, observes Professor Henry, "to determine, by his own observation, the relations of the standard barometers used by the Smithsonian Institution with the most important standards of the European observatories; and it is believed that these comparisons establish a correspondence of the European and American standards within the narrow limit of one or two thousandths of an inch."\*

Besides the general survey of New York topography, Guyot carried forward, during his leisure weeks of the summer and autumn, a study of the altitudes and orography of the Appalachian chain, or the mountain system of eastern North America, in which work he had encouragement from appropriations by the Smithsonian Institution. He commenced, as early as 1849, a barometric exploration of the White Mountain system of New Hampshire, and continued his work at the North until he had spent five years over New Hampshire, the Green Mountains in Vermont, and the Adirondacks, and other parts of New York.

From these more northern portions of the Appalachian system he went to Virginia and North Carolina. In July of 1856 he measured barometrically twelve of the highest peaks of the Black Mountains in North Carolina, all of them higher than the White Mountains of New Hampshire. He was occupied with this southern part of the system from that time till late in the summer of 1860, when his measured heights in that region of endless forests and great altitudes had increased in number until they exceeded one hundred and eighty; how much exceeded his paper does not say, as the altitudes determined in 1860 remain still unpublished. Besides these measurements, he made his survey complete by extending a net-work of triangles over the area (nearly 150 miles in length), so fixing the positions of the peaks and ridges.

In a letter of October 3, 1859, he writes, speaking of his work of that season in the Smoky Mountains, "the culminating range of North Carolina": "My trip to the Smoky Mountains was a long and laborious

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\*Professor Henry's report to the Regents of the Smithsonian Institution for the year 1862. The observatories with which the comparisons were made were that of Kew, then under the direction of Stanley; that of Brussels, under Quetelet; that of Berlin, under Encke, and that of Geneva, under Plantamour, who had already compared the Geneva barometer with that of the Collège de France and that of the Observatory of Paris.



one. Much rain, great distances, imperviable forests, delayed me two months. I camped out twenty nights, spending a night on every one of the highest summits, so as to have observations at the most favorable hours. The ridge of the Smoky Mountains I ran over from beginning to end, viz, to the great gap through which the Little Tennessee comes out of the mountains."

Having thus far finished his study of the mountain system, a new map of the whole Appalachian chain, made under his direction by his nephew, Mr. Sandoz, was published in 1860, in the July number of Petermann's "Mittheilungen." This map, with some emendations, was republished in 1861, in volume XXXI (second series) of the American Journal of Science, in illustration of an accompanying paper on the Appalachian system. This paper, after a brief history of his work, presents his results in an orographic description of the mountain region and an explanation of the laws which he had deduced, together with tables of more than three hundred altitudes.

His "thousands of measurements" in the Alps had prepared him for accurate and thorough work here. As evidence of exactness, his barometric measurement of Mt. Washington in 1851 gave for the height 6,291 feet; the measurements by spirit-level made by N. A. Godwin, civil engineer, in 1852, gave 6,285 feet, and a similar levelling under the direction of the Coast Survey in 1853 gave 6,293 feet. So, again, the Black Dome of North Carolina, made 6,707 feet by him, was measured with a spirit-level by Maj. J. C. Turner, civil engineer, setting out from Guyot's point of departure, and the height made 6,711 feet.

There was still left unmeasured the heights of the Catskill Mountain range. In 1862 he went to work in this region, and continued it, as before, during his summer and autumn vacation months until the close of the summer of 1879, excepting the year 1871, when he took a trip to California for his health and some barometric work in the Rocky Mountains and the Coast Range. Gray's Peak, in Colorado, was one of the heights ascended and measured—an easy walk for *him*, said the young men of the party.

The Catskill region, a plateau of "piled-up strata owing its mountain forms chiefly to sculpturing waters," had its difficulties. Although so near New York and the Hudson River, and frequented each summer by thousands of tourists, it was to a large extent, especially over the southwestern part, an untracked wilderness of forests. In several cases his only chance for making his triangulation was by climbing to the tops of the highest trees, and then there was difficulty in identifying the distant, featureless, forest-buried summits. Moreover, many peaks had no names, and again the same name was often found to be used for two or three different peaks. He accomplished his work nevertheless, and when finished had gratifying proof of his great accuracy in spite of the difficulties. One point in the triangulation, the extreme western, was in common, as he afterwards found, with that of the State survey



of New York, under Mr. James T. Gardiner; and "in the position of this station," he says, writing August 12, 1849, "we agree perfectly."

He discovered, by his explorations in the Catskills, nineteen summits that were higher than the highest previously known, three of them over 4,000 feet above tide-level. For the highest, called "Slide Mountain," he found the elevation 4,205 feet, while that of "High Peak," which had been thought the highest, proved to be only 3,664 feet.

This work, closing so grandly Guyot's study of the Appalachian system—begun by him when he was forty-two years of age, was finished in 1881 when seventy-four. It was his "vacation" work. His memoir on the Catskills was published in 1880 in volume XIX (third series) of the *American Journal of Science*, with two illustrating maps. The orographic structure of the range is described, its origin briefly and judiciously considered, and the heights given for over two hundred points. A larger map (14 by 20 inches) was issued the year before as a pocket map. And thus his orographic labors have already contributed greatly to the convenience of tourists as well as to geographical science.

Guyot's first scientific work, fifty years since, and his last was mountain work. And I think I am safe in saying that no one before him, if any since, can claim to have made with the barometer more numerous and more accurate hypsometric measurements; his field books make the number of such measurements by him over twelve thousand. In all his explorations he manifested that unflagging energy and thoroughness which are required for accurate work. At the same time his acuteness of intellect and well-furnished mind, while demanding the fullest investigation for final results, led him quickly and surely in the path toward right conclusions, as was strikingly manifested in the outcome of those six weeks in 1838 over the glaciers. Besides these qualities of the careful and judicious observer his ever searching mind, as shown by his comprehensive views on the earth, living nature, and man, was remarkable for its powers of philosophical analysis and generalization. The combination of the thorough student of facts in nature with the far-seeing student of principles and fundamental law has seldom been more complete, and we may therefore well describe him as in a remarkable degree—using his own language—"a harmonic unit."

The two friends from Switzerland, Guyot and Agassiz, were both needed by the country when they reached its shores. Each performed a work among us of great service to education as well as to science, and we owe them lasting gratitude. But their change of base in coming to America gave them a position for wider influence over the world, and American gratitude is not all that is due them.

In recognition of Guyot's services to science he was elected to honorary membership in several learned societies, among them the Geographical Society of London, and that of Paris; and since his decease a geographical society has been organized at Neuchâtel, this being, in

the words of Prof. Louis Favre, "the finest monument that could be erected to the memory of a savant who had brought so much honor to his native land."

In 1867 Guyot married a daughter of the late Governor Haines, of New Jersey, a lady of intelligence and refinement, who made for him the happiest of homes; and his gentleness, consideration, and warmth of heart fitted him to contribute his share to that happiness.

Guyot's face and manner betokened deep and earnest thought rather than enthusiasm and quiet self-possession without self-assertion. A man of medium height, deep-set eyes, and spare figure, he looked as if made more for thinking than for acting, and yet his power of walking and climbing seems to have had no bounds, and scarcely failed him at all until after his three-score and ten had been passed. The greatest ascents gave his well-trained muscles no more fatigue than a walk in his garden; and pathless tangled forests for-weeks in succession, with nights in the wild woods, were a source of great enjoyment. On the 29th of December, 1883, hardly six weeks before his decease, he wrote to the president of the Society of Natural Sciences of Neuchâtel, M. Coulon, after congratulating him on keeping up his walks to Chaumont, although then eighty years of age, "Even last year I could have told you of my seventy-six years and my ability still to climb our mountains, but unhappily it is not so now."\*

His special weakness was a virtue in excess, an unobtrusiveness that disinclined him to assert himself, that made him too easily content with work without publication. Hence his results and original views often failed of recognition, and but one of his projected works of the higher series was ever completed. In a letter of November 15, 1858, in replying to one who had urged him to publish, he says: "And I am A. G., who thinks a good deal and delights in it, but is too easily satisfied with that selfish pleasure." Yet much of this reluctance was, as before said, owing to the hesitation of his critical mind in the use of the English language. Besides, he was ever waiting for more facts. And, too, he was overburdened, as he often said, with his educational labors. In accordance with his unassuming ways, he did not become a naturalized citizen of his adopted country until 1860, he feeling, rather than reasoning, that a foreigner should not hasten to intrude himself into political affairs.

Although indisposed to push himself, still, when in conversation with a man of like intelligence, he was sure to command eager attention, and, without other effort, to find places of honor and congenial work open to him. Within six months of his arrival in the country, a talk in Philadelphia with Professor Henry gained for him the position of a virtual manager in the meteorological department of the Smithsonian Institution, and, by similar means, there came about his connection with the

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\* Memorial sketch of A. Guyot, by Prof. L. Favre, vice-president, Bull. Soc. Sci. Nat. Neuchâtel, xiv, 327, 1884.

Massachusetts board of education. Through his wealth of ideas, not self-effort, he secured the several high positions occupied by him in the country.

Guyot was a man of devoted friendships. He manifested this deeply in his tribute to his old teacher, Carl Ritter, and in that to his compatriot, Agassiz. There was no limit to his good-will. Children of his acquaintance knew this, and all who had the privilege of intercourse with him. On the 7th of November, 1864, he writes from Princeton, "I have bought the house in which I live, and my care has been to prepare and shape the garden for the next season according to my taste. A quiet green retreat to study and write, and good friends visiting me in it and filling it with the warm rays of affectionate friendship, is an ideal for which, if realized, I should heartily thank God."

Guyot was a fervently religious man, living as if ever in communion with his heavenly parent; a Christian, following closely in the footsteps of his Master. His search into nature's phenomena and laws was a search for divine truth and a divine purpose. His field-notes of 1850 contain the entry: "On n'est fort qu'avec la vérité, et ce que m'importe c'est de l'avoir de mon côté. Dieu sait que je la désire avant tout, et il me fera la grace de la reconnaître." In his trip to Europe in 1861, he went as a delegate from the Presbyterian Church of America to the convention of the Evangelical Alliance which met that year in Geneva. He writes from Paris under date of October 24, just before his return, of his "great pleasure in attending, in that old stronghold of Protestant faith, the large and exceedingly interesting meeting," and in witnessing the "grand spectacle of so many sympathizing Christians from all quarters of Christendom uniting in the services with perfect freedom and unanimity." And then he shows his kindly nature in allusions to "the testimonies of love and true friendship" which had greeted him everywhere in his journey through Europe and the land of his youth, and in expressions of thankfulness "for those old affections" and those "deep sympathies which are destined, by their very nature, to outlive our mortal frames."

His Neuchâtel pupil, Mr. Faure, well observes: "He cared little for renown, but much for the study of nature and for the education of man." As fellow-students, we have special reason to admire in Guyot—as he wrote of Humboldt—"that ardent, devoted, disinterested love of nature which seemed, like a breath of life, to pervade all his acts; that deep feeling of reverence for truth so manifest in him which leaves no room for selfish motives in the pursuit of knowledge, and finds its highest reward in the possession of truth itself."

Arnold Guyot died at Princeton on the 8th of February, 1884. Funeral services were held in the church, where the officers and students of the college and other friends were gathered with the relatives of the deceased, and excellent memorial discourses were pronounced by Rev. Horace Hinsdale and Dr. James Murray, dean of the college. His remains lie buried in the Princeton cemetery. •



## LIST OF THE WRITINGS OF PROF. ARNOLD GUYOT.

1835. Inaugural Dissertation, at Berlin, on the Natural Classification of Lakes. (In Latin.)
1835. Numerous contributions to the *Encyclopédie du XIX<sup>ème</sup> Siècle*, Paris. Among them the more extensive are on Germany, Physical Geography of Germany, and on the System of the Alps.
1838. On the Structure of Glaciers and the Laws of Glacier Motion. Read before the Geological Society of France in 1838, but not published until 1883.
1842. On the Ribbed Structure of the Glacier of Gries. From the paper of 1838. Read before the Soc. Sci. Nat. de Neuchâtel December 1, 1841, and published in abstract in the *Verhandl. d. Schweiz. Nat. Gesellschaft*, Altdorf, 1842, pp. 199, 200. Published in full, excepting the last part, in *New Phil. J.*, Edinburgh, xxxv, 1843, in a paper on Agassiz's Glacial Researches, by Desor; also in Tyndall's *Glaciers of the Alps* (1856), and his *Forms of Water* (1872); also in full in Agassiz's *Système Glaciaire* (1847).
1842. Observations on the Erratic Phenomena of Lower Switzerland and the Juras. *Verhandl. d. Schweiz. Nat. Ges.*, Altdorf, for July, 1842, pp. 132-145.
- 1843, '45, '47. Observations on the Erratic Phenomena of Switzerland. *Bull. Soc. Sci. Nat.*, Neuchâtel, for November, 1843, May and December, 1845, and January, 1847.
1844. On the Law of the Formation and Distribution of Glacier Crevasses.
1847. Erratic Phenomena in the Alps. Abstract in D'Archiac's *Hist. Progr. Géol.*, vol. II, pp. 259-265.
1849. *Earth and Man, or Lectures on Comparative Physical Geography in its Relation to the History of Mankind*. 310 pp. 8vo. Boston. Second edition in 1850.
1850. On the Upheaval of the Jura Mountains by Lateral Pressure. *Proc. Amer. Assoc.*, II, 115. Read before the association in August, 1849.
1850. Directions for Meteorological Observations. For the observers of the Smithsonian system of meteorological observations.
1852. Meteorological and Physical Tables. 212 pp. 8vo. Prepared for and published by the Smithsonian Institution. A second edition in 1857, 639 pp.; a third edition in 1859, received an addition of 70 pages; a fourth edition in 1884, 738 pp.
1852. On the Topography of the State of New York. *Rep. Regents Univ. New York* for 1851, p. 232. Albany. Reprinted in *Am. Jour. Sci.*, 2d ser., XIII, 1852.
1859. Address at the Humboldt commemoration of the American Geological Society in October, 1859. *Jour. Amer. Geogr. and Statist. Soc.*, I, No. 8, 1859, pp. 242-245.
1860. Carl Ritter: An address to the American Geographical Society, February 16, 1860. *Jour. Amer. Geogr. Soc.*, II, No. 1, 1860, pp. 25-63.
1861. On the Physical Structure of the Appalachian System of Mountains, with a physical map of the system. *Amer. Jour. Sci.*, 2d ser., XXXI, 157.
1861. Altitudes in North Carolina and Georgia. *Geol. Rep. North Carolina* of 1861, and also of 1875.
- 1866-75. A series of School Geographies, six volumes, including a Physical Geography. A series of wall maps, containing thirty maps.
1873. A Treatise on Physical Geography. Johnson's Family Atlas of the World.
1874. Cosmogony of the Bible, or the Biblical Account of Creation in the Light of Modern Science. *Rep. of the Sixth Gen. Conference of the Evangelical Alliance*, in New York, 1873.



- 1874-'77. Many articles in Johnson's Encyclopædia, of which Professor Guyot was one of the editors-in-chief.
1875. Memoir of James Coffin. Read before the National Academy of Sciences.
- 1877-'78. Memoir of Louis Agassiz. Read before the National Academy of Sciences October 23, 1877, and April, 1878. Published at Princeton. 50 pp. 8vo. April, 1883. Biographical Memoirs of the Academy, vol. II.
1879. Physical and Orographic Map of the Catskill Mountain Region. Size, 14 by 20 inches.
1880. On the Physical Structure and Hypsometry of the Catskill Mountain Region, with two plates. Amer. Jour. Sci., 3d ser., XIX, 429. Communicated to the National Academy of Sciences in part at sessions in 1875 and 1876.
1883. On the Existence in Both Hemispheres of a Dry Zone and its Cause. Amer. Jour. Sci., 3d ser., XXVI, 161. Read before the National Academy of Sciences November, 1882.
1884. Creation, or the Biblical Cosmogony in the Light of Modern Science. 136 pp. 12mo. New York.

PAPERS COMMUNICATED TO THE NATIONAL ACADEMY, BUT NOT DEPOSITED IN MANUSCRIPT.

- August, 1864. At the meeting at New Haven. On the influence of the hour of the day on the results of barometric measurements of altitudes.
- August, 1865. Northampton. On the probable cause of the Glacial Epoch of the Post-tertiary.
- August, 1866. Northampton. On the influence of the hour of the day on the heights obtained by barometric measurements.
- January, 1868. Washington. On the practical character of the usual thermometric scales, and a common substitute for them.
- August, 1869. Northampton. On the law of distribution of volcanoes and its bearing on the theory of volcanic action.
- April, 1873. Washington. On the altitude of Gray's and Torrey's Peaks, in Colorado; some questions connected with the determination of barometric altitudes in the interior of continents.
- On the unity of the system of life in animals and the true principle of gradation in the various animal types.

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